Chemical Engineering

A McGRAW-HILL PUBLICATION

JUNE 2, 1958

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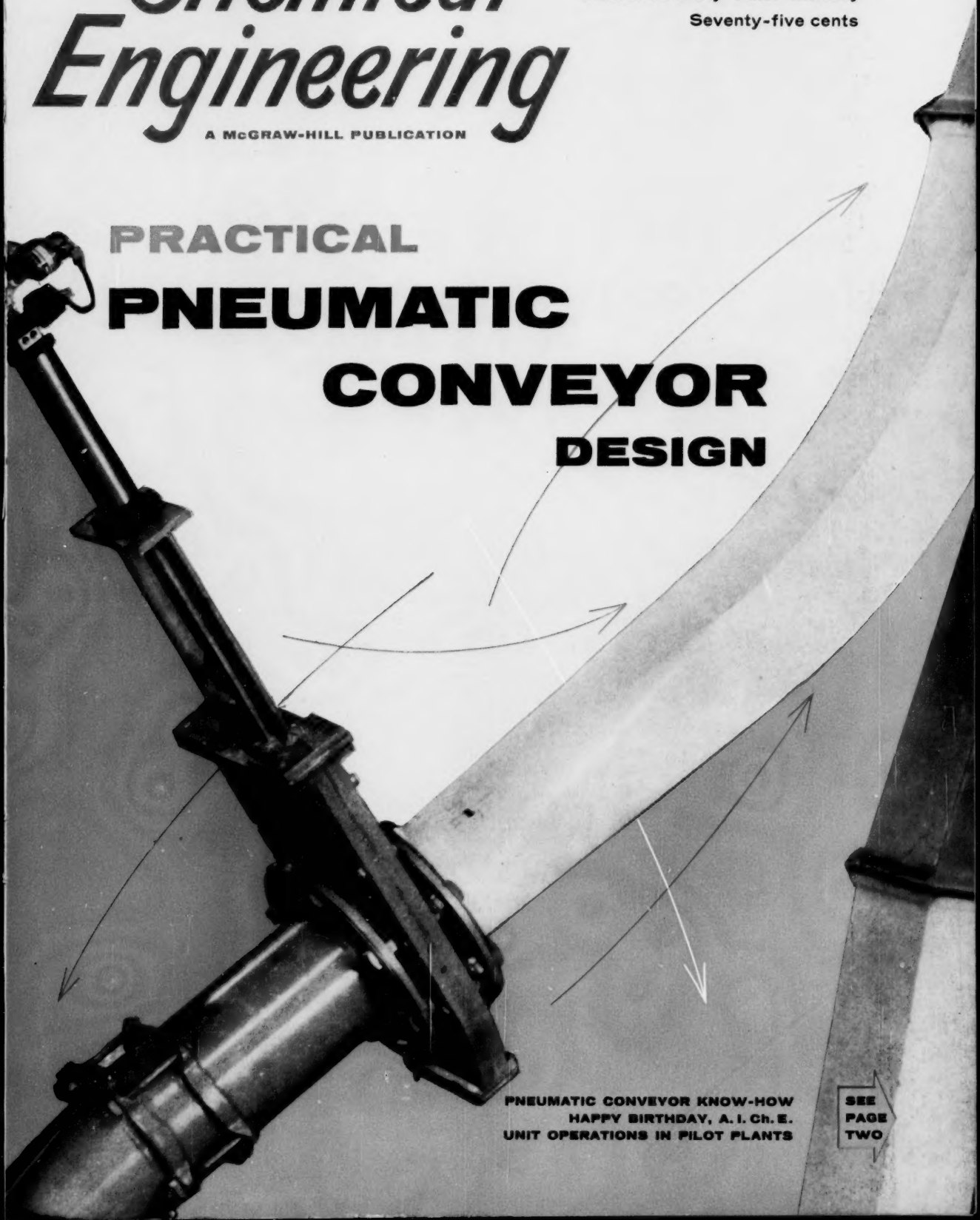
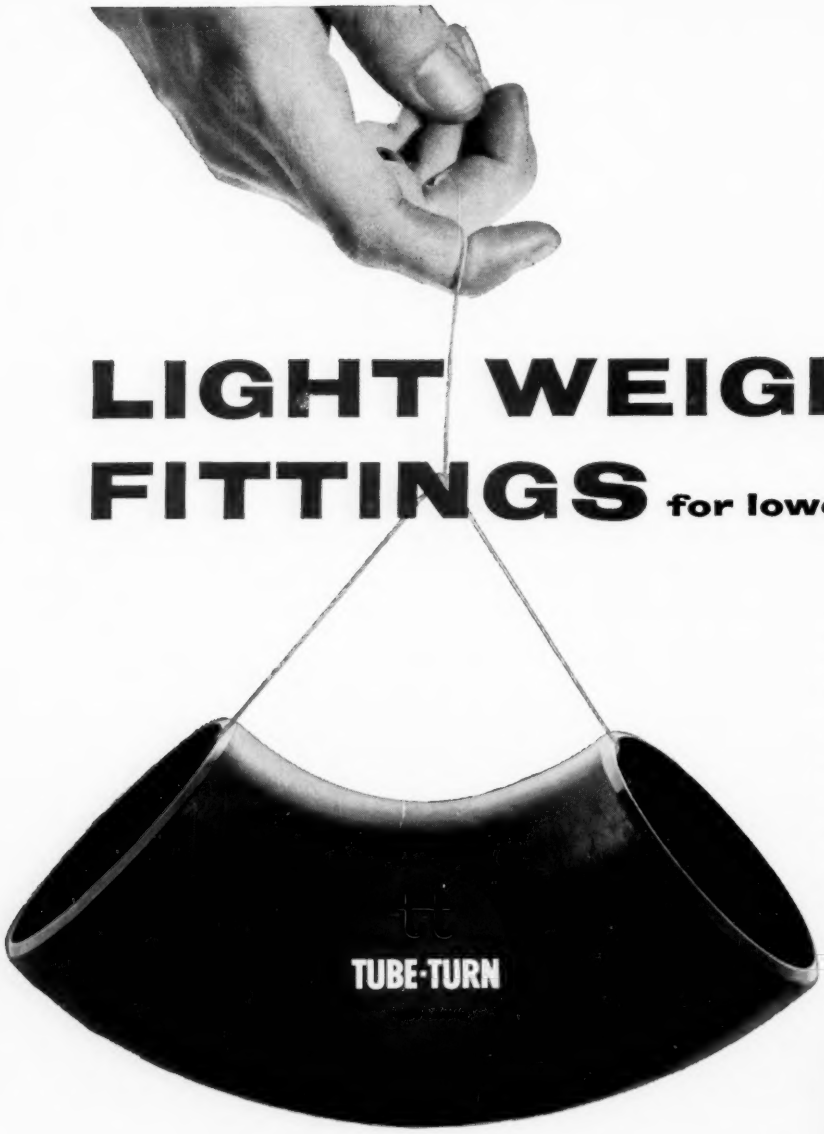
Seventy-five cents



PRACTICAL PNEUMATIC CONVEYOR DESIGN

SEE PAGE TWO



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from Tube Turns...

LIGHT WEIGHT FITTINGS for lower-cost piping

Light weight piping makes practical the use of larger pipe for greater flow area, and it cuts costs and weight. To enable you to take full advantage of the economies of "thin wall" steel piping, Tube Turns offers a complete line of light weight fittings. TUBE-TURN® Light Weight Welding Fittings are produced under the same exacting quality control standards as the 12,000 other items in the Tube Turns' line. They are available promptly from your nearby Tube Turns' Distributor.

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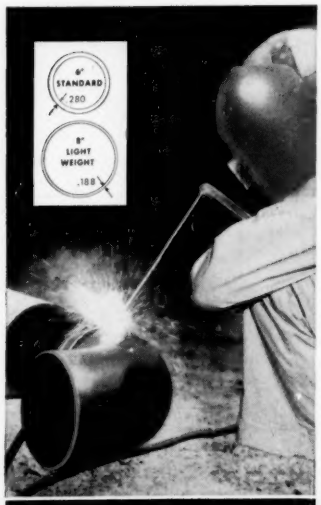

Available in nominal sizes from 4" through 24" in wall thicknesses of .188, .219 and .250 inch. Also, 125 lb. light weight taper face welding neck flanges in sizes 2" - 12" inclusive.

How you cut costs! A typical user of light weight steel piping reports these benefits: 100 feet of 8" x .188" wall pipe costs about $10 less than 100 feet of 6" standard weight pipe; increases flow area 85%; cuts piping weight about 10%. To enable you to take full advantage of these economies, Tube Turns offers a complete line of light weight fittings. They are forged from seamless pipe. Meet all code requirements. Uniform wall thickness and true circularity permit field cutting of odd angles.

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JUNE 2, 1958

JOHN R. CALLAHAM, Editor-in-Chief

Tribute To and From AIChE

In this issue we pay tribute to the AIChE and to its fifty years of service to the profession of chemical engineering (see p. 111).

So, in this issue, it's also fitting to mention the tribute that the AIChE itself has just paid to one of our own editors—Sid Kirkpatrick—and to his many years of outstanding contributions to the profession.

Sid's latest honor is the Founders' Award. Designated by the Institute's Council, it will be presented for the first time at the Fiftieth Anniversary meeting in Philadelphia. Other recipients this year are T. H. Chilton of Du Pont, J. V. N. Dorr of Dorr-Oliver, O. A. Hougen of Wisconsin and W. K. Lewis of MIT.

Sid's active participation in AIChE has covered a span of over 30 years. He has been a member of numerous committees, director for three terms, vice president in 1941 and president in 1942. In 1932 he received the Institute's Silver Anniversary Medal. With W. G. Whitman, he now heads up the Institute's membership fund-raising drive for the United Engineering Center.

On the editorial staff of CE and its predecessor (*Chem & Met*) for 37 years, Sid was editor for 22 years (1928-1950), editorial director since 1950. During all these years he has remained a staunch champion of chemical engineers; more than any other person, he has molded CE into a publication dedicated to the recognition and service of chemical engineers and of their profession.

For this reason we feel that the Institute's tribute to Sid through the Founders' Award is also a tribute to CE and its 56 years of contributions to the chemical engineering profession.

ELEVENTH OF TWENTY-SIX ISSUES

11/26

GUIDED TOUR

How design factors influence selection of pneumatic conveyors

Here you have an introduction to the first steps in pneumatic conveyor design and selection. It is real background information that—until now—has been difficult to get. And with it you'll be better equipped to select, operate and maintain these versatile systems for transporting dry bulk materials to and from processing. (p. 114)

New ion exchange for thick pulps

Modified columns now make it possible to use ion exchange on thick pulps without filtering. Vibrating screens take out oversize solids, tapered-hole screens keep resins in column. (p. 56)

Three keys to new rubber process

Three key improvements feature this continuous process for butadiene-styrene rub-

Chemical

JUNE 2, 1958

GUIDED TOUR

ber: reactors in series, falling-film strippers a specially-designed carbon black master-batch step. (p. 102)

When to pilot unit operations

How the development engineer can decide which operations need piloting, which can be omitted because good correlations are available. How this knowledge can save both time and money. (p. 119)

How to predict diffusion coefficients

You have very few diffusivity data. And they're needed in calculations for many common mass transfer processes. So these prediction and extrapolation methods will be valuable as well as reliable. (p. 125)

No undue shortage of engineers!

That's the clear-cut conclusion from a recent exclusive survey. Most chemical engineers say there's no undue shortage in their ranks. Any lack, they believe, is more in quality than quantity. (p. 131)

CE is edited for the engineer concerned with chemical operations, whatever his function . . . administration, production and plant operations, design and construction, research and development, sales and purchasing. More engineers subscribe to CE than to any other magazine in the field. Print order this issue:

47,469

Developments in Chemical Engineering

Practice of Chemical Engineering

Engineering

Vol. 65, No. 11

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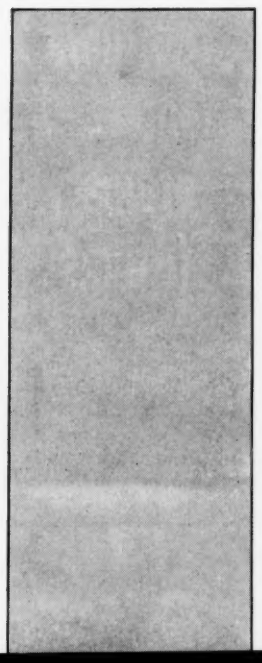
Chemical Engineering

This issue's top features of significance in

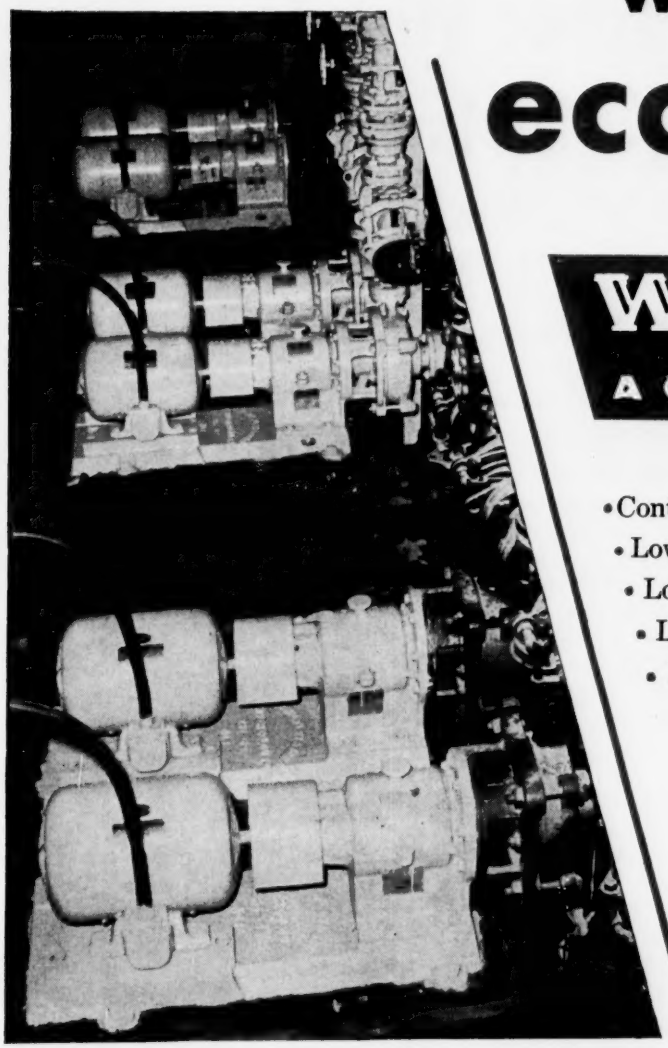
Petrochemicals & Petroleum Refining

JUNE 2, 1958

Also of Basic Interest



Here are **the** acid pumps with built-in economy



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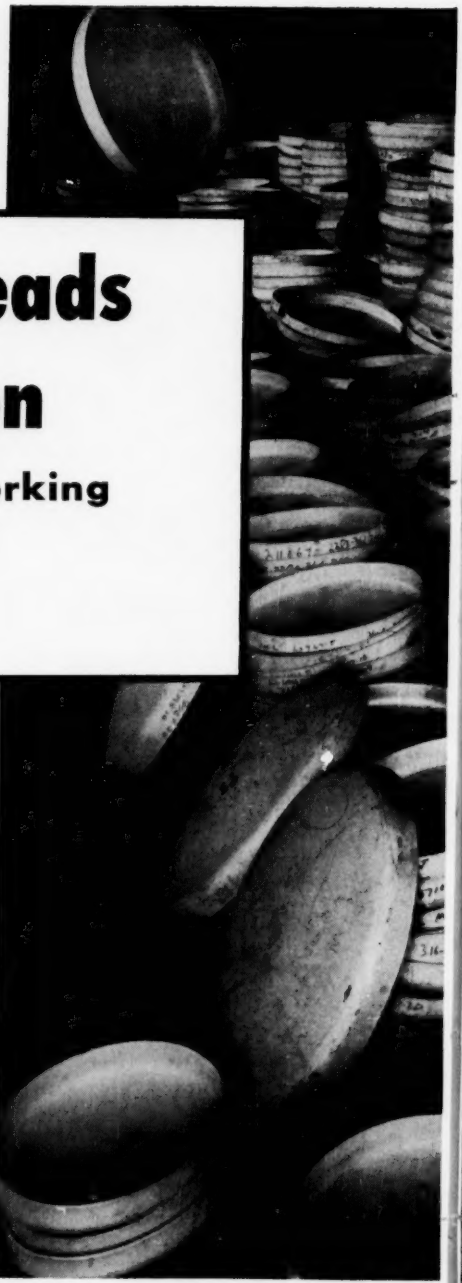

Stainless Steel Heads stocked by Carlson

- keep your working capital working
- save you money
- give you prompt delivery

It pays to design and build equipment with this stock in mind. You don't have to tie up your working capital in shell plates, pipe and fittings while you wait eight or ten weeks for tank heads. You'll save money by using the less expensive stock sizes that are pressed, rather than odd sizes that must be spun. You also save time when you need stainless steel heads for new construction or for emergency replacement.

The Carlson stock is made up of ASME and Standard flanged and dished stainless steel heads. They range from 10″ O.D. through 72″ O.D., in 6″ increments, $\frac{3}{16}$″ through $\frac{3}{8}$″ Gauge, in Types 304, 304-L, 316, and 316-L. All are fully annealed and pickled after forming to provide maximum corrosion resistance. Flanges can be machined to your specifications in a matter of days.

In addition to maintaining the country's largest stock of stainless steel heads, dies are available for pressing heads in other grades of stainless. Special sizes can be spun when required. To get all the facts on this unusual Carlson service, mail the coupon and we'll send you the latest Heads File-Folder and Stock List.

G.O.CARLSON Inc.

Stainless Steels Exclusively

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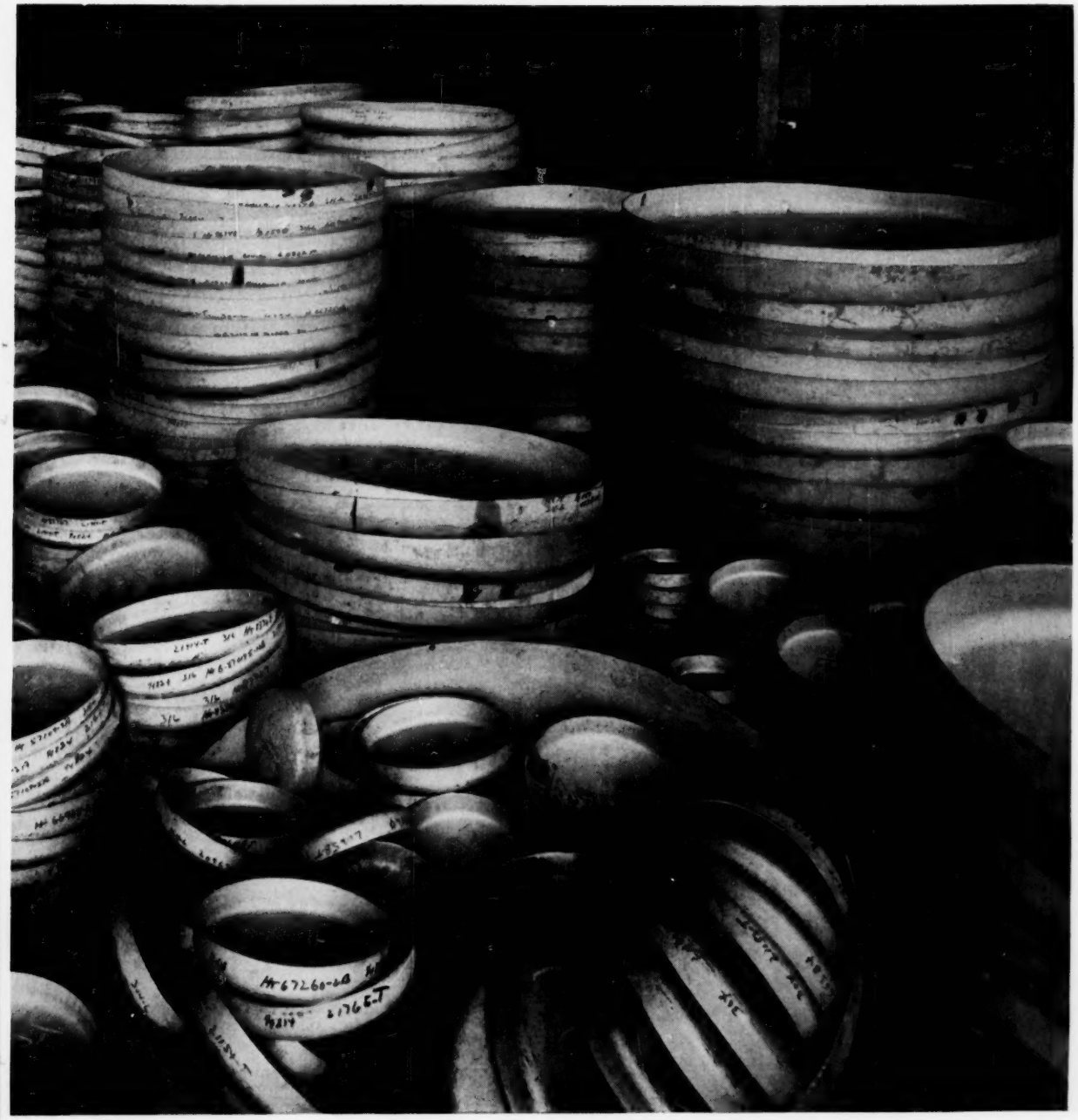
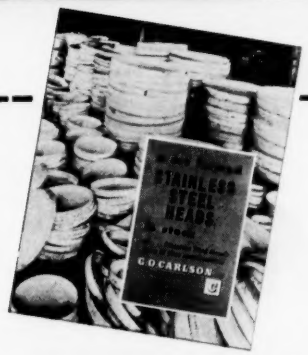
This Carlson Stainless Steel Heads File-Folder includes lists of Dies for press forming and information on flange machining.

PLATES • PLATE PRODUCTS • HEADS • RINGS • CIRCLES • FLANGES • FORGINGS • BARS and SHEETS (No. 1 Finish)





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G. O. Carlson, Inc.
134 Marshalton Road
Thorndale, Pennsylvania

Please send me your Heads File-Folder and Stock Lists.

Name: _____

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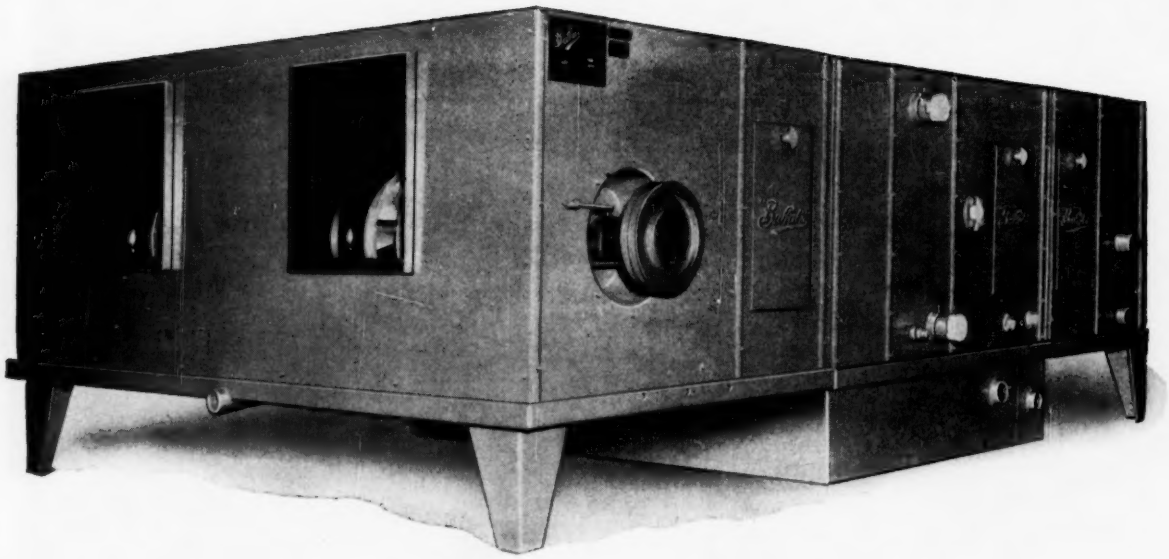

"BUFFALO" UNITS ACCURATELY CONTROL PLANT ATMOSPHERE

Require only Routine Maintenance

If your manufacturing processes require accurately controlled atmospheres, "Buffalo" units provide outstanding installations for high quality production. These quiet, efficient, dependable units are available in combinations for every possible application: for cooling or complete air conditioning — including cooling and de-humidifying, heating and humidifying, and/or continuous air cleaning. Any or all of these functions may be automatically controlled.

Add to performance the well-known "Q" Factor* of construction quality and you see why "Buffalo" units are ideal for rugged industrial service.

Extra heavy gauge sheet and structural members are used to give rigidity, eliminate distortion and vibration. Strategically located access doors facilitate inspection and maintenance. Motors and bearings are located where they are easy to lubricate and service.

For your next plant atmosphere control installation, be it modernization or new construction, be certain the air handling units are "Buffalo". Complete information may be obtained from your "Buffalo" Engineering Representative or write direct outlining your requirements.

**The "Q" Factor* — the built-in Quality which provides trouble-free satisfaction and long life.*

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BUFFALO, NEW YORK

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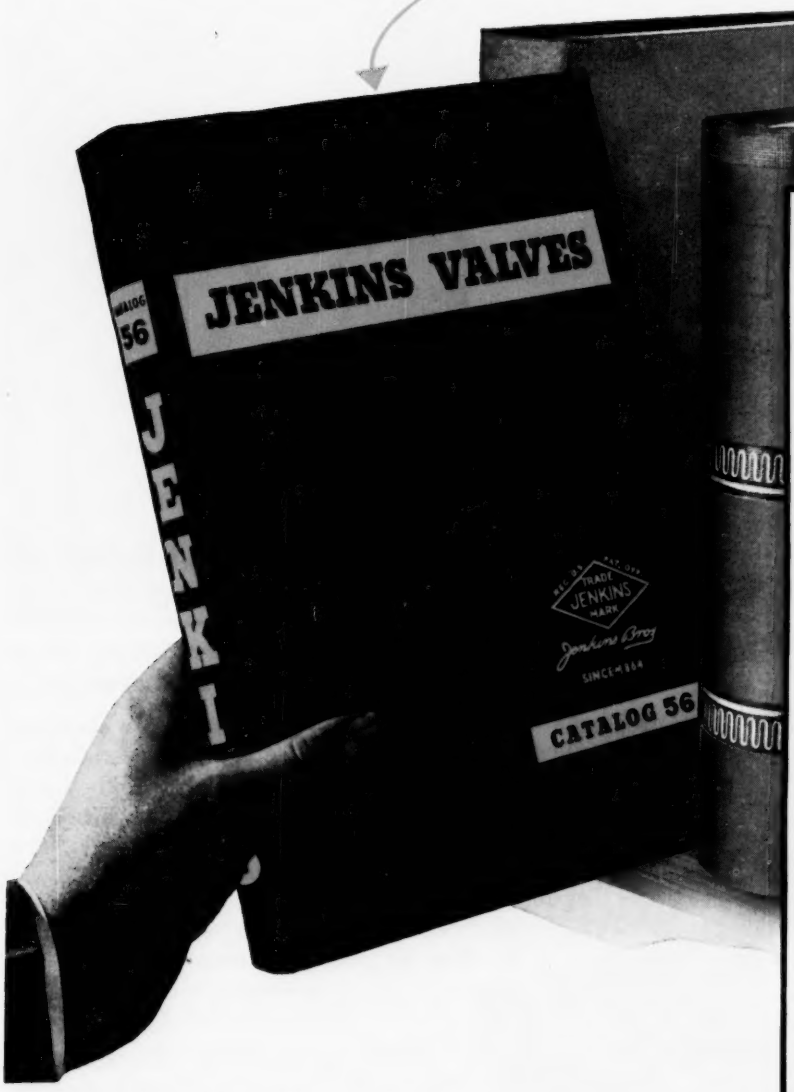

HELPFUL FEATURES

FOUR TYPES OF INDEXES LEAD QUICKLY TO DATA NEEDED
Four-way indexing—General, Alphabetical, Fig. No., and Sectional—leads the reader instantly to the information desired, from any point of reference . . . pattern, metal, number, or function.

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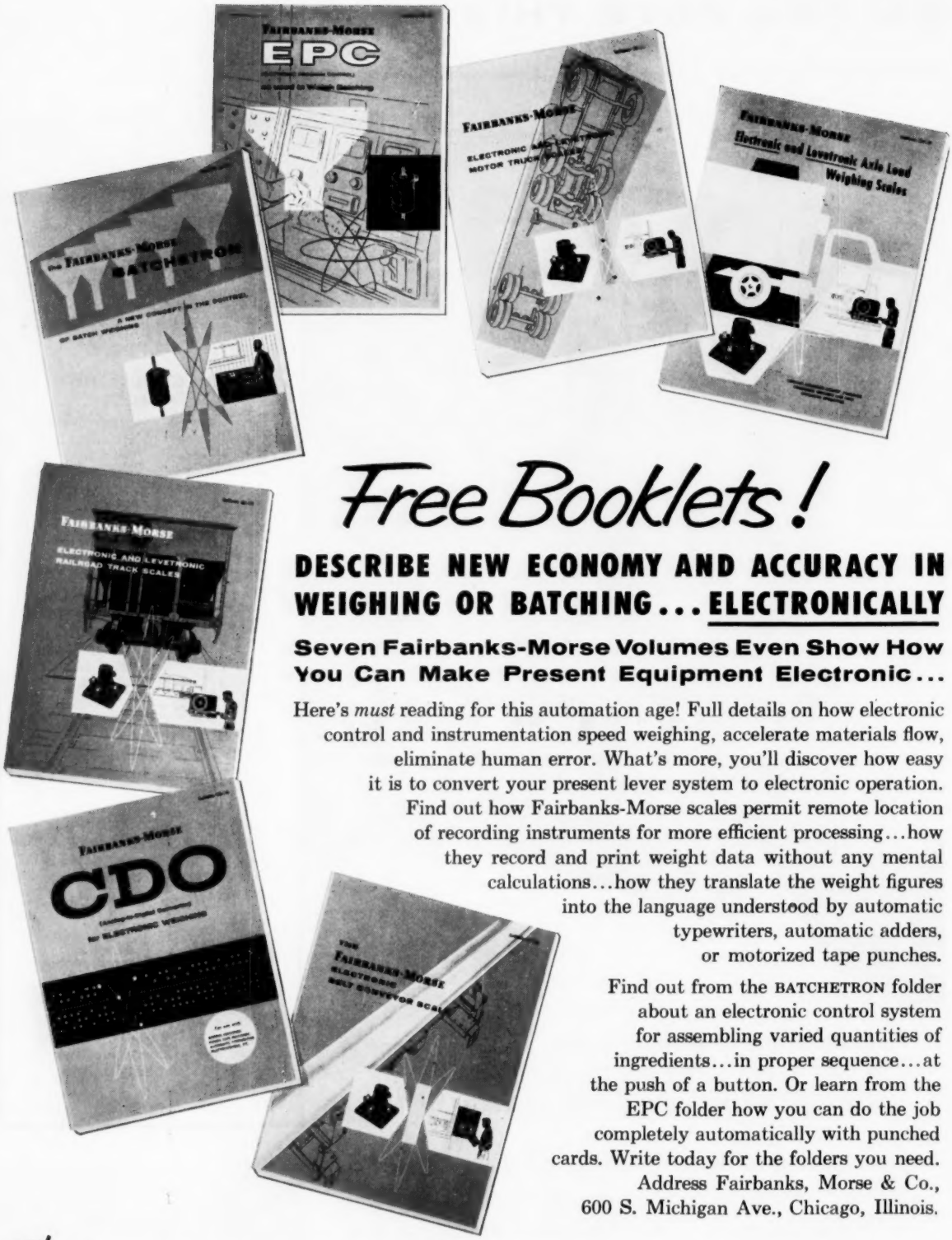

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Seven Fairbanks-Morse Volumes Even Show How You Can Make Present Equipment Electronic...

Here's *must* reading for this automation age! Full details on how electronic control and instrumentation speed weighing, accelerate materials flow, eliminate human error. What's more, you'll discover how easy it is to convert your present lever system to electronic operation. Find out how Fairbanks-Morse scales permit remote location of recording instruments for more efficient processing...how they record and print weight data without any mental calculations...how they translate the weight figures into the language understood by automatic typewriters, automatic adders, or motorized tape punches.

Find out from the BATCHETRON folder about an electronic control system for assembling varied quantities of ingredients...in proper sequence...at the push of a button. Or learn from the EPC folder how you can do the job completely automatically with punched cards. Write today for the folders you need. Address Fairbanks, Morse & Co., 600 S. Michigan Ave., Chicago, Illinois.

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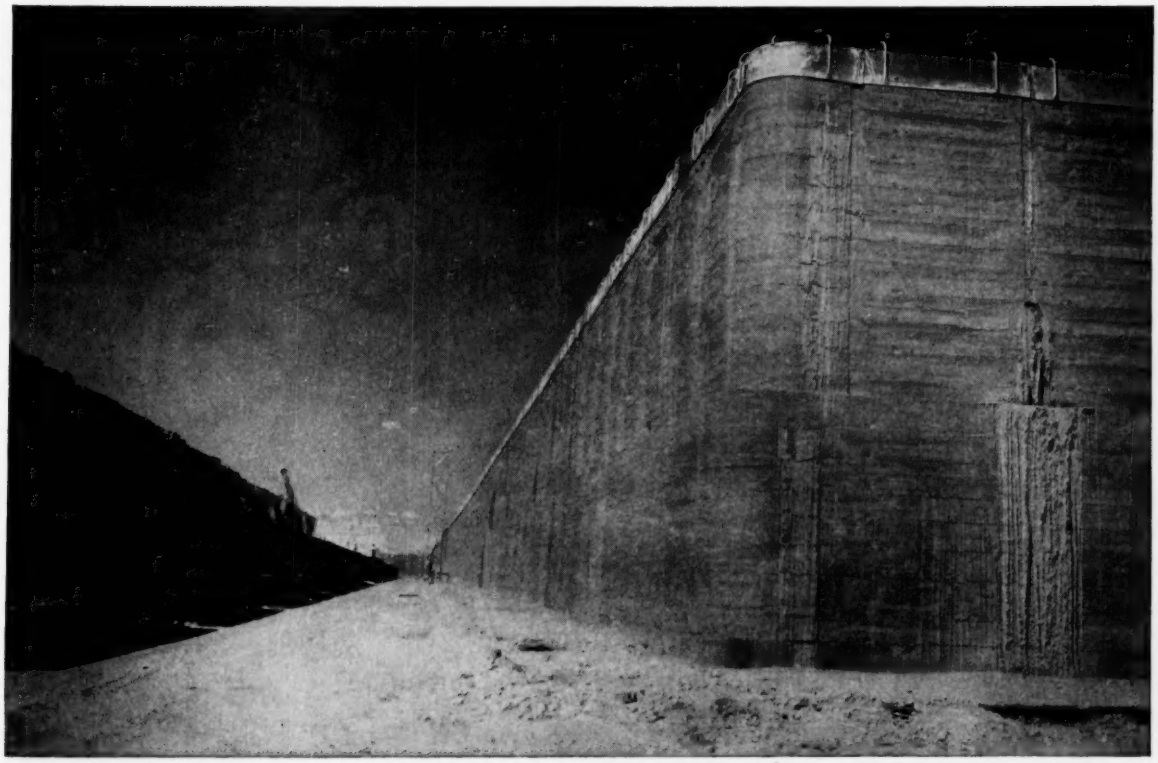

Stockpiling

...a continuing company policy established years ago

Stockpiling is a measure of service.

The government is stockpiling strategic materials for its long range defense program. Thus, it serves the citizenry. The producer of a raw material who as a company policy stockpiles also serves . . . serves its customers who in turn serve others by being able to count on a supply of the raw material in quantity.

The policy of Texas Gulf Sulphur Company has always been to stockpile . . . always producing *extra* for the future. In spite of the growing demands for the important basic material it produces—Sulphur . . . the company's policy has been to keep on hand stocks equal to about a year's normal demand. With such a supply, it can make shipments, routine or emergency, of any tonnage, at any time, by any method.

Texas Gulf Sulphur Co.

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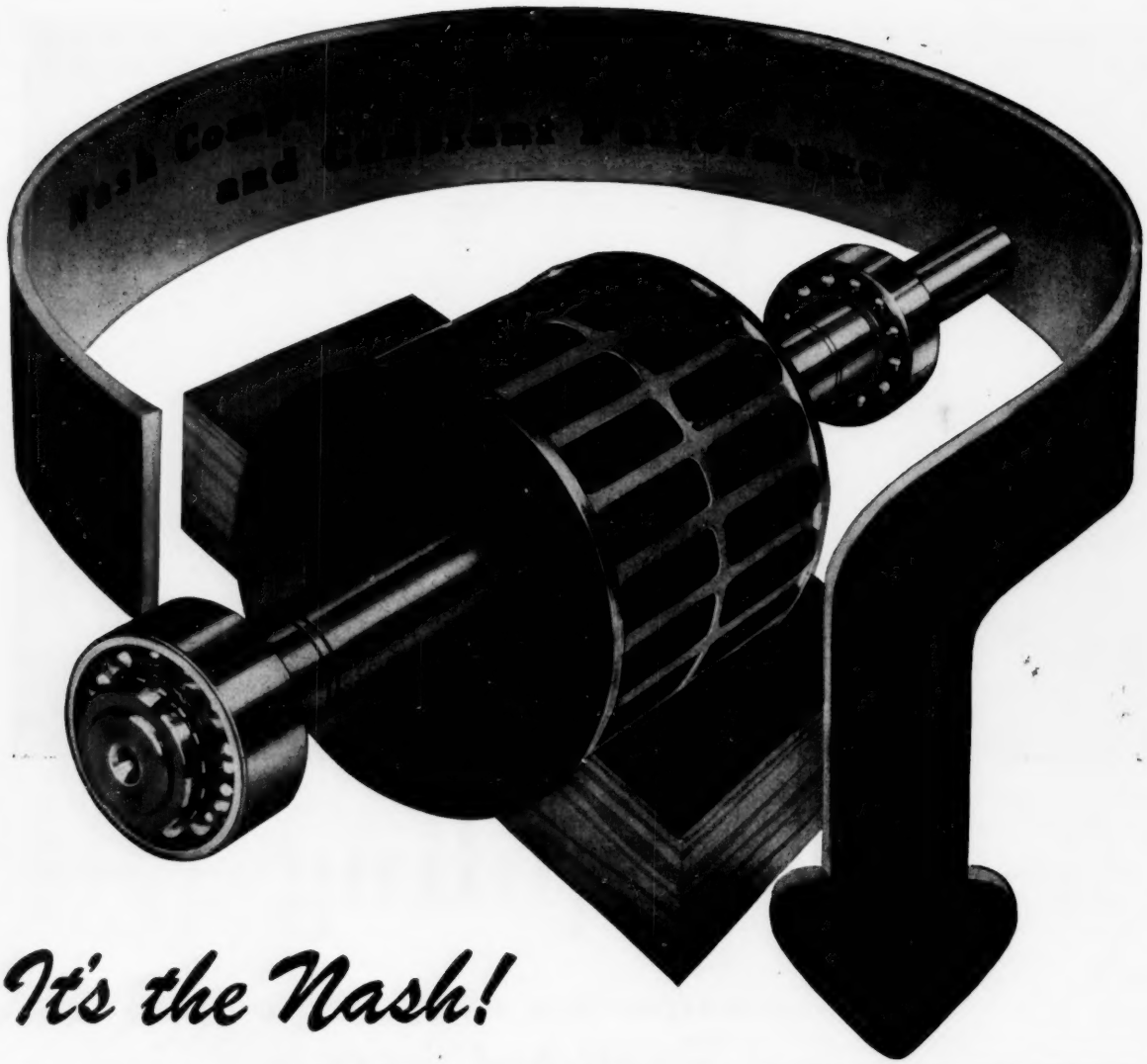
811 Rusk Avenue, Houston 2, Texas

Sulphur Producing Units — Newgulf, Texas; Moss Bluff, Texas; Spindletop, Texas; Worland, Wyoming



It's the Nash!

The ability of Nash Compressors to maintain original performance over long periods is no accident. Nash Compressors have but a single moving element, the Nash Rotor. This rotor is precision balanced for long bearing life, and it revolves in the pump casing without metallic contact. Internal lubrication, frequent cause of gas contamination, is not employed in a Nash. Yet, these simple pumps maintain 75 lbs. pressure in a single stage, and afford capacities to 6 million cu. ft. per day in a single compact structure.

Nash Compressors have no valves, gears, pistons, sliding vanes or other enemies of long life. Compression is secured by an entirely different principle of operation, which offers important advantages often the answer to gas handling problems difficult with ordinary equipment.

Nash Compressors are compact and save space. They run without vibration, and compression is without pulsation. Because there are no internal wearing parts, maintenance is low. Service is assured by a nation-wide network of Engineering Service offices. Write for bulletins now.

No internal wearing parts.

No valves, pistons, or vanes.

No internal lubrication.

Low maintenance cost.

Saves floor space.

Desired delivery temperature Automatically maintained.

Slugs of liquid entering pump will do no harm.

75 pounds in a single stage.

NASH ENGINEERING COMPANY

312 WILSON, SO. NORWALK, CONN.

Now, from U. S. Steel, you get maximum product protection plus two important purchasing advantages—at no extra cost

Chemically cleaned, then coated with extra zinc phosphate – every rust-inhibited U. S. Steel drum gives you maximum product protection.

But that's not all.

With every U. S. Steel drum *and* every U.S. Steel pail, you automatically get two extra purchasing advantages that can help you save time and money.

1. Full, complete line. U. S. Steel offers today's widest selection of steel shipping containers. From 2½-gallon pails through 57-gallon drums – *plus* a complete line of stainless-steel containers. This wider line allows you to fill all your needs at one time, in one place, with absolute confidence.

USS IS A REGISTERED TRADEMARK.

2. Punctual deliveries. U. S. Steel's seven convenient plants assure you of a smooth, even flow of containers—by rail, or in a special fleet of trucks. Our kind of service helps reduce both inventory and production problems. Your normal needs are filled without delay, rush orders get there quicker, too.

Maximum protection, simplified purchasing, punctual deliveries—U. S. Steel gives you all these extras at no extra cost. Why don't you talk over your steel shipping container requirements with the man from U. S. Steel?

Factories in: Los Angeles, Calif. · Alameda, Calif. · Port Arthur, Texas · Chicago, Ill. · New Orleans, La. · Sharon, Pa. · Camden, N. J.

PROOF OF U. S. STEEL PROTECTION! Both these 55-gallon drums were weathered for 12 months. Rust appeared on the ordinary drum the first week. U. S. Steel rust-inhibited drum—coated with zinc phosphate—shows no trace of rust whatever.

United States Steel Products Division

USS

Largest New Cooling Tower Installation Is Fungus-Proof

The recent installation of 40 fan cells of Marley Double-Flow cooling towers at one location is outstanding in capacity and in pre-determined durability, too, because every foot of the 1,715,000 board feet of lumber used was **MARLITH** pressure protected after fabrication.

This huge installation highlights industry's growing concern over the greatest hazard to cooling tower service — **FUNGAL DECAY**. **MARLITH** treatment is a most positive and economical step to prevent the destructive action of fungi — a hazard the country and the world over. The efficacy of **MARLITH** treatment has been proved conclusively in hundreds of laboratory and field tests in many parts of the world.

There can be no question that the accumulated costs of maintenance and down time for an unprotected cooling tower will, over the years, far exceed those of a **MARLITH**-treated tower. Most important, **MARLITH** treatment assures for the future an adequate supply of cold water at an efficient operating temperature — a factor virtually as important as your basic materials supply.

If water conservation is in your development plans (it's good business for you, your neighbor, your country), you'll find it profitable to get full information from your Marley engineer on **MARLITH** — the "life insurance" for your cooling towers. Just ask him or write for Marlith Bulletin M-58.

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MARLEY®

Pays for itself in Savings!

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CONTROLLED-VOLUME CHEMICAL PUMP

NO LEAKAGE
NO CONTAMINATION
NO PRIME LOSS
NO STUFFING BOX

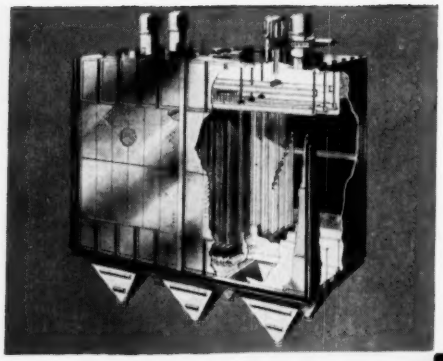
The moment your new Pulsafeeder is put into operation, you're on the way to real savings . . . savings that can eventually result in the Pulsafeeder paying for itself.

Lapp Pulsafeeder, the chemical pump with *no stuffing box,* is a piston-diaphragm pump providing *positive displacement* by a piston pumping a hydraulic medium working against a diaphragm. The diaphragm isolates the chemical being pumped from the working pump parts . . . eliminates need of stuffing box or running seal . . . prevents corrosion. Maintenance costs are reduced to next to nothing—there are practically no repairs or replacement of parts with a Pulsafeeder. You'll save, too, by elimination of product loss due to leakage or contamination. In the long run, Pulsafeeder is the safest, surest and lowest cost controlled-volume chemical pump. To prove our stand, we'll be happy to quote actual maintenance costs taken from recorded case histories.

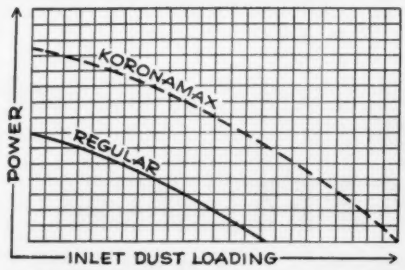
Lapp

WRITE FOR BULLETIN 440 *with typical applications, flow charts, description and specification of models of various capacities and constructions. Inquiry Data Sheet included from which we can make specific engineering recommendation for your processing requirement. Write Lapp Insulator Co., Inc.,*

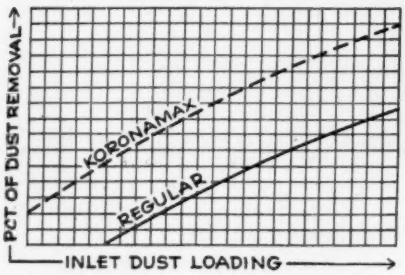
PROCESS EQUIPMENT DIV., 3601 Poplar St., LeRoy, N. Y.



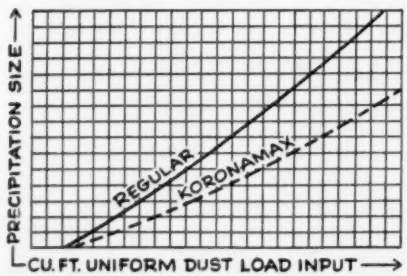
Another Koppers Exclusive in ELECTROSTATIC PRECIPITATION



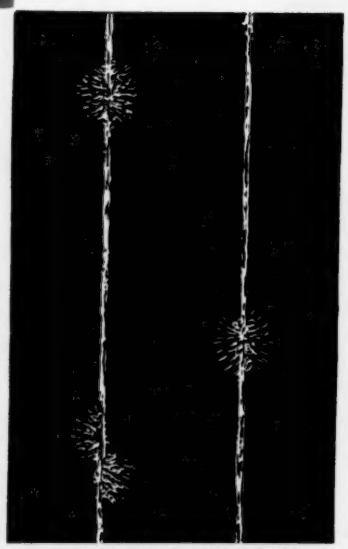
INCREASED POWER—The evenly spaced discharge points of "Koronamax" Electrodes reduce the arc-over tendency and permit increasing power input.



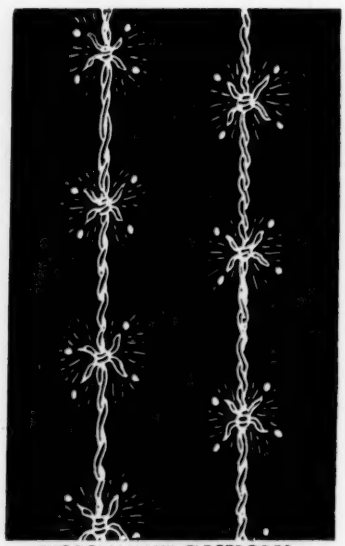
HIGHER EFFICIENCY—Replacement of regular electrodes with "Koronamax" Electrodes allows higher power input — greatly increased efficiency.



SMALLER SIZE—In new installations desired efficiency may be obtained with smaller unit when "Koronamax" Electrodes are used.



CONVENTIONAL ELECTRODES



"KORONAMAX" ELECTRODES

"KORONAMAX" ELECTRODES increase efficiency and capacity of electrostatic precipitators

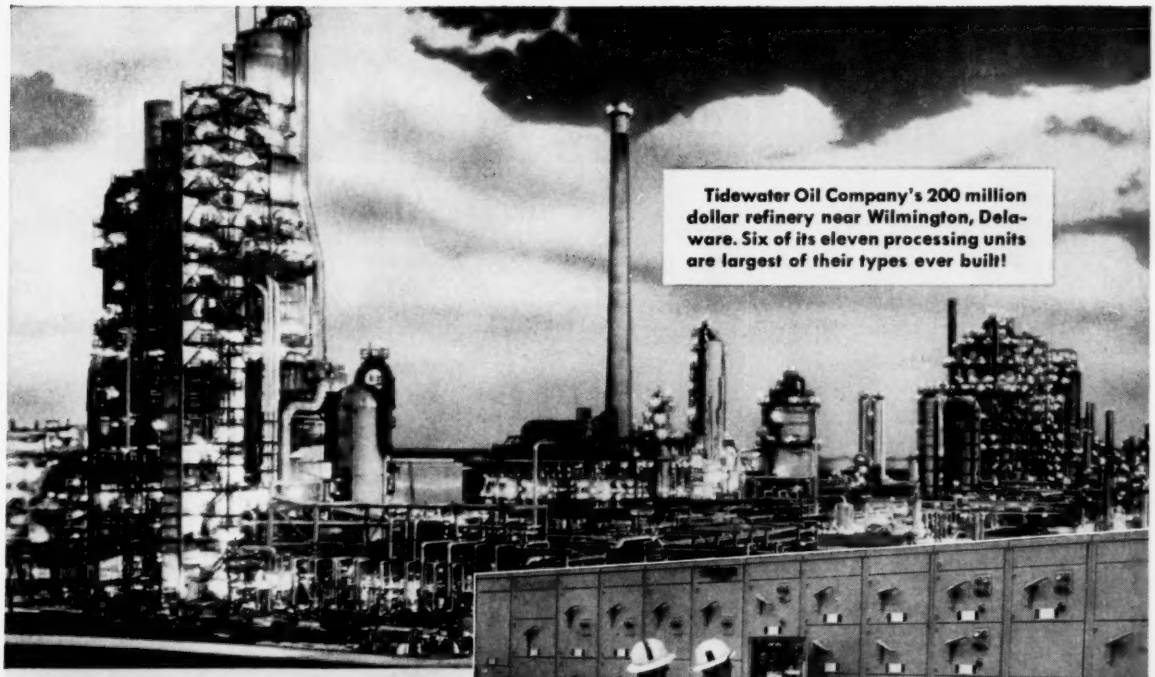
"Koronamax" Electrodes developed by Koppers are now in service in several different applications and their *controlled* corona discharge has resulted in greatly increased capacity and efficiency. This unique type of precipitator electrode may solve *your* gas cleaning problem.

Koppers' experience, constant research and extensive field testing have led to this important advance in precipitator design. Check with Koppers to see if "Koronamax" Electrodes can help you get top precipitator efficiency. For more information, write: KOPPERS COMPANY, INC., 9706 Scott Street, Baltimore 3, Md.

KOPPERS

ELECTROSTATIC PRECIPITATORS

Engineered Products Sold with ***Service***



Tidewater Oil Company's 200 million dollar refinery near Wilmington, Delaware. Six of its eleven processing units are largest of their types ever built!

SQUARE D CONTROL CENTERS

serve New

TIDEWATER REFINERY

Here's Why Square D is Your Logical Choice, too!

INCREASED SAFETY! • Bus bars fully enclosed, rigidly supported and have ample cross section. Circuits isolated by individually enclosed plug-in units. Disconnect handle gives maximum operator protection.

FLEXIBILITY! • Individual plug-in units or complete sections easily added, removed or exchanged. Pushbuttons, pilot lights, and selector switches readily added to unit doors.

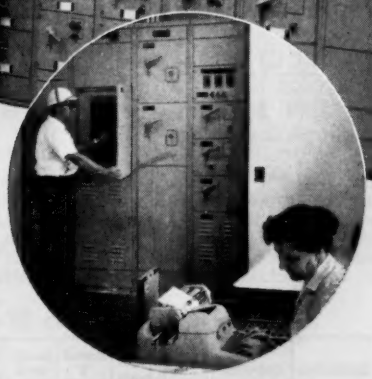
INSTALLATION ECONOMY! • All wiring channels are large and accessible from front without removing units. No "wire fishing."

SPACE ECONOMY, TOO! • Up to six combination starters fit in a 20" x 90" section. Plug-in unit heights designed in space-saving increments of 3".

SUPERIOR DESIGN you can actually see and feel. Practical, modern styling. Greater structural strength gives more rigidity and assures precision alignment.

Write for **CONTROL CENTER BULLETIN...**

Square D Company, 4041 N. Richards St., Milwaukee 12, Wis.

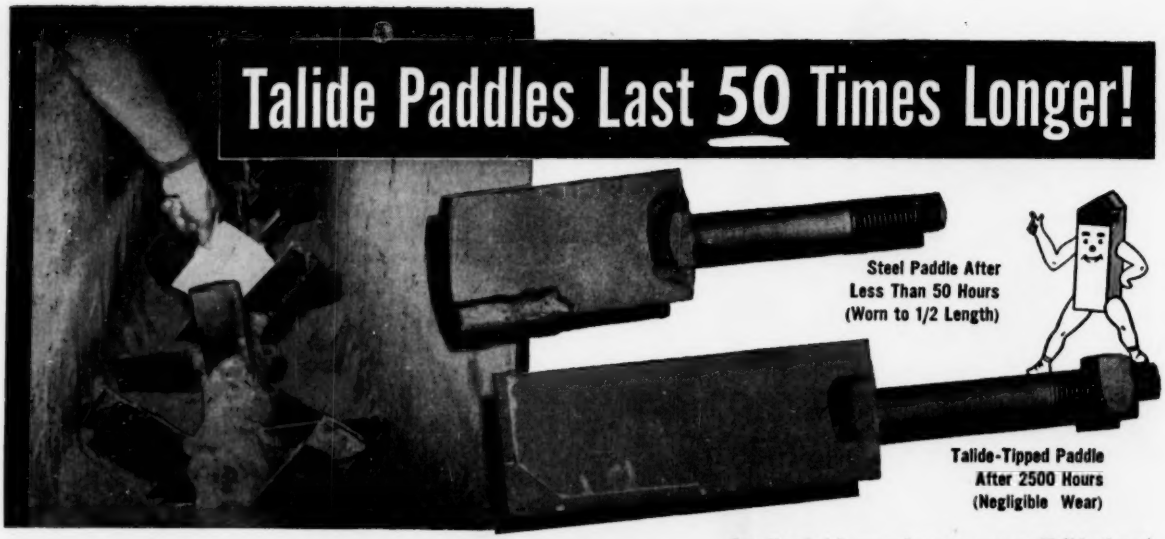


(Top photo) In the refining area **Square D Control Centers** provide a portion of the centralized control of pumps and compressors. In the maintenance shop they control power, heating, ventilating and lighting.

(Lower photo) Another Square D Control Center, located in the Employe Relations Building, provides pushbutton control of air-conditioning units and compressors. Infirmary X-Ray equipment and parking lot lighting also are remotely controlled from this Center.

EC&M HEAVY INDUSTRY ELECTRICAL EQUIPMENT...NOW A PART OF THE SQUARE D LINE

SQUARE D COMPANY



HARDEST MAN-MADE METAL!

TALIDE METAL, a tungsten carbide of superior quality, is harder, stronger, and more resistant to abrasion than any other metal. Properly applied, it gives superior service on applications where wear, heat, strain, and shock are destructive to other metals.

- **ABRASION RESISTANCE**— Up to 100 times that of steel.
- **COMPRESSIVE STRENGTH**— Higher than all melted, cast or forged metals and alloys.
- **RESISTANCE TO DEFORMATION**— 2 to 3 times greater than steel.
- **HEAT RESISTANCE**— Resists oxidation and thermal shock up to 1500° F.
- **THERMAL EXPANSION**— Less than half the rate of steel, "creep" is negligible.
- **FRICTIONAL RESISTANCE**— Lower than steel, non-galling, "slippery" properties higher.

ALL TALIDE METAL grades are made in latest type vacuum electric furnaces by precision methods under rigid control. A wide variety of shapes and sizes can be supplied—up to 25" in diameter, 100" in length, and 5000 pounds by weight. Parts can be supplied to any grit finish required down to one micro-inch. The physical properties of the most commonly used grades are listed below. Other grades are available for specialized applications.

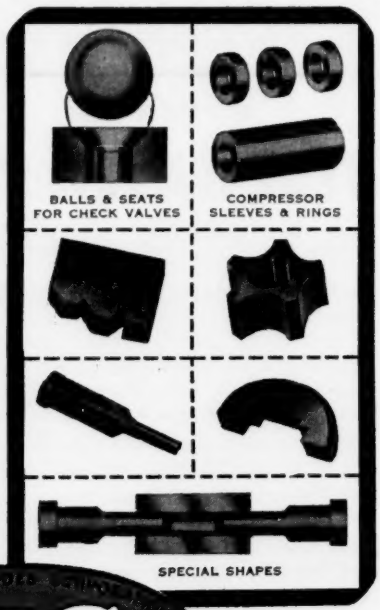
PHYSICAL PROPERTIES OF TALIDE METAL (P. S. I.)

Application	Operation	Talide Grade	Rockwell "A" Hardness	Specific Gravity (Density)	Transverse Rupture Strength	Compressive Strength	Co-Efficient of Thermal Expansion	Modulus of Elasticity (Deflection)
WEAR SURFACE	No Shock	C-91	91.8	14.90	235,000	710,000	3.00x10-6	91,000,000
	Light Shock	C-99	91.0	14.75	265,000	670,000	3.65x10-6	84,000,000
	Medium Shock	C-88	89.5	14.55	295,000	635,000	4.00x10-6	80,000,000
IMPACT	Light	C-85	88.4	14.25	315,000	600,000	3.75x10-6	77,000,000
	Medium	C-80	87.0	13.85	335,000	550,000	4.50x10-6	74,000,000
	Heavy	C-75	85.0	13.15	355,000	500,000	5.00x10-6	70,000,000

Note: Hardness values may vary plus or minus .2 to .3 on individual lots.

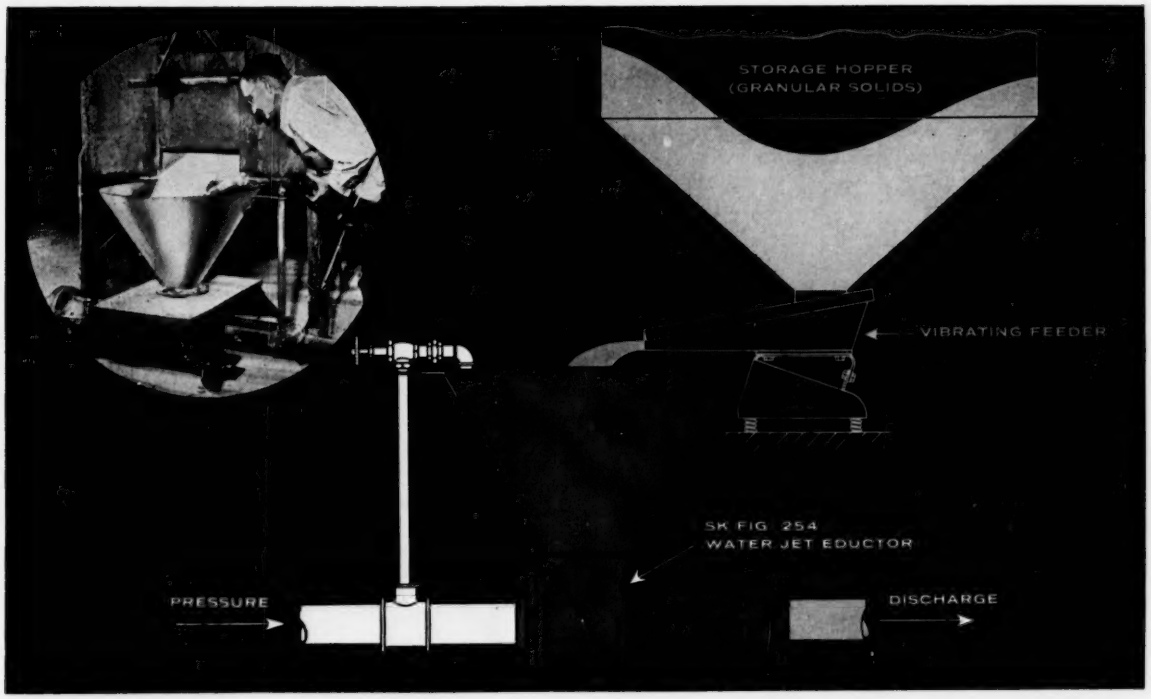
Leading brick manufacturer reports Talide-tipped pug mill paddles have outlasted 50 sets of hard-faced steel paddles to date—and are still in use. Operation involves mixing abrasive ceramic, clay and brick compositions.

TALIDE METAL is saving industry millions of dollars annually by wear-proofing vital parts on machine tools, presses, pumps, compressors and other types of processing equipment used in the steel, oil, chemical, plastic, auto, rubber, textile, glass, ceramic, mining and metalworking industry.



Send for new 76-page catalog 56-G or ask for sales engineer to call.

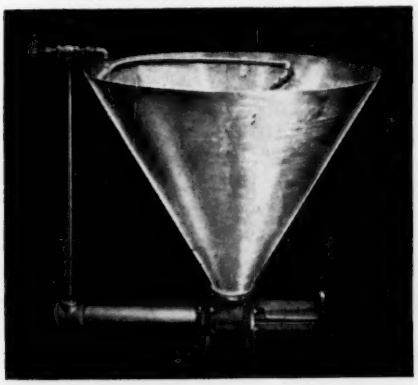
Metal Carbides Corporation
Youngstown 12, Ohio



MIX SOLIDS WITH LIQUID, CONVEY SLURRIES

with this SK "Hopper Type" Water Jet Eductor

SK Fig. 254 Hopper Type Water Jet Eductor



SK's Hopper Type Eductor, shown above and at left, will mix solids with liquid and convey slurries conveniently and at low cost. See box below for types of granular solids currently being handled.

An inexpensive unit, this light-weight eductor is easy to install, simple in construction with no moving parts, requires little maintenance, and provides efficient service over long periods. In operation, pressure water, issuing through the nozzle, entrains granular solids from the hopper and discharges through discharge piping. Agitating jets keep material moving down into the eductor.

Used in the petroleum industry, in chemical processing and food processing plants, the hopper eductor has proved to be extremely satisfactory in handling the materials (bulk densities noted) listed below and others.

For full details on Hopper Type Eductors including sizes, capacities, ratios, water consumption, materials of construction, write to SK for Bulletin 2M.

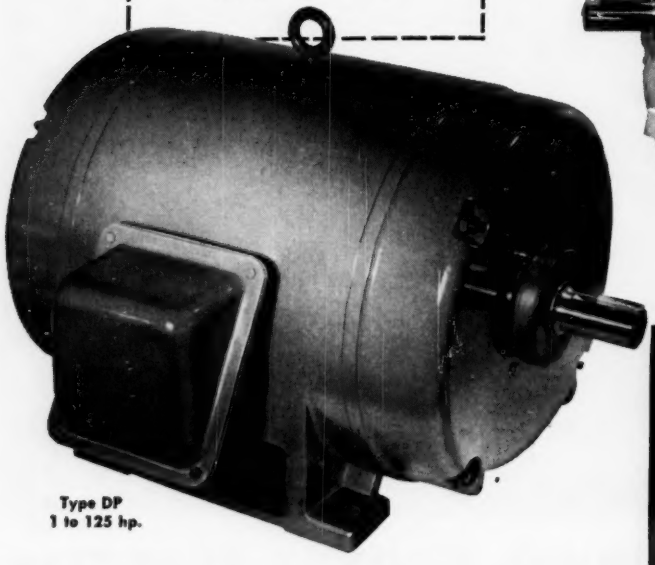
SK HOPPER EDUCTORS ARE BEING USED CURRENTLY TO HANDLE THE FOLLOWING MATERIALS *(Approx. Bulk Densities Indicated in Parentheses)*

Borax (50-55)
Charcoal (18-28)
Diatomaceous Earth (10-20)
Lime, Pebble (56)
Lime, Powdered (32-40)
Mash (60-65)
Fly Ash (35-40)
Rosin (67)
Salt, Granulated (45-51)
Salt, Rock (70-80)
Sand, Damp (75-85)
Sand, Dry (90-100)
Sawdust, Dry (13)
Soda Ash, Light (20-35)
Sodium Nitrate, Dry (80)
Sulphur, Powdered (50-60)
Wheat (48)
Zinc Oxide, Powder, Dry (10-35)

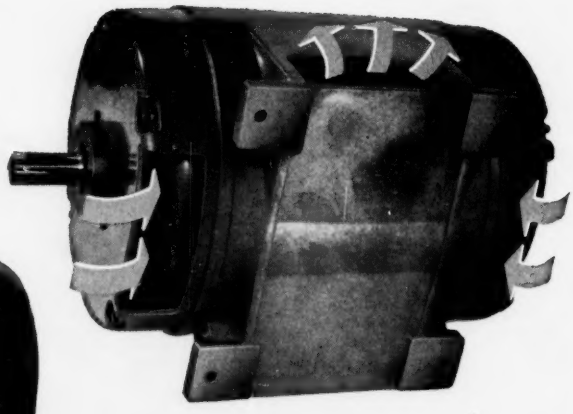
JET APPARATUS: Ask for Condensed Bulletin J-1.
ROTAMETERS & FLOW INDICATORS: Ask for Condensed Bulletin M-1.
VALVES: Ask for Condensed Bulletin V-1.
HEAT TRANSFER APPARATUS: Ask for Condensed Bulletin HT-1.
GEAR PUMPS: Ask for Bulletin 17-A.

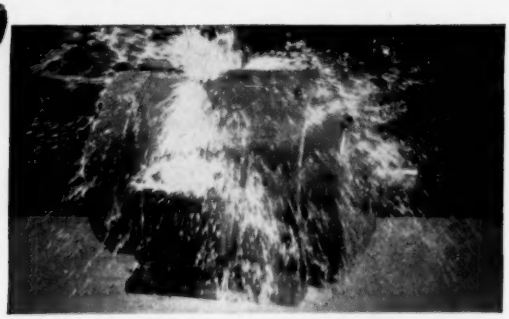
Schutte and Koerting
COMPANY
MANUFACTURING ENGINEERS SINCE 1876
2217 State Road, Cornwells Heights, Bucks County, Pa.

WAGNER
POLYPHASE
MOTORS



Type DP
1 to 125 hp.





DOUBLY PROTECTED — Wagner DP Motors offer the *double protection* of completely dripproof enclosures and rugged cast iron frames that can take rough handling and resist corrosion.

These open type motors give DOUBLE PROTECTION... can be used in many places that formerly required splashproof motors

Wagner Type DP Motors offer the *double protection* of rugged corrosion-resistant cast iron frames and dripproof enclosures so well designed that the DP Motor can handle many applications that formerly required splashproof motors.

These Wagner Motors are built in the new NEMA ratings that pack more power into less space, are lighter in weight and are easier to maintain—only occasional lubrication is required.

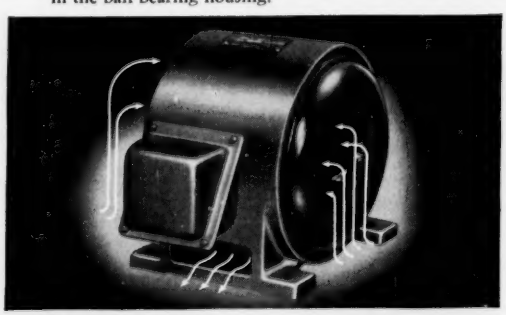
SLEEVE BEARING MODELS AVAILABLE

The entire line of ratings through 125 hp. is available with steel-backed, babbitt lined sleeve bearings that have high carrying capacity and provide quieter operation.

Let a Wagner Sales Engineer show you how these motors can be applied to your needs. Call the nearest branch office or write for Wagner Bulletin MU-223.

1 to 125 HP—1750 RPM—40°C NEMA FRAMES 182 through 445U

CAN BE RELUBRICATED — These motors can be re-greased when desired for longer bearing life. Fresh grease can be added—old grease removed—through openings provided in the ball bearing housing.



COOL RUNNING — Specially designed baffles direct cooling air through the motor to protect the stator windings. Blowers, cast as part of the rotor, move large volumes of air without noise or vibration.

Wagner Electric Corporation
6407 Plymouth Ave., St. Louis 14, Mo., U.S.A.

WH58-8

BRANCHES AND DISTRIBUTORS IN ALL PRINCIPAL CITIES

"SPECIAL" Welding Fittings

by MIDWEST

"SPECIAL" DESIGNS

"SPECIAL" MATERIALS

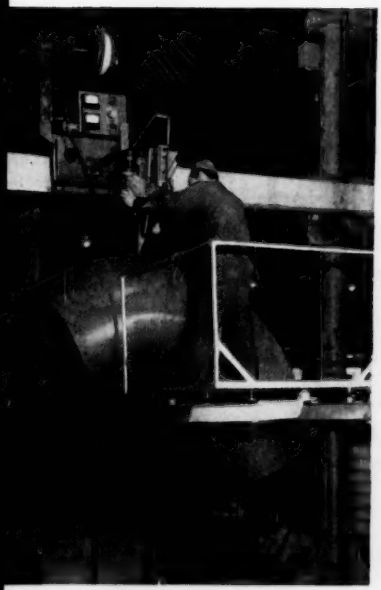
"SPECIAL" QUALITY

"SPECIAL" DELIVERY

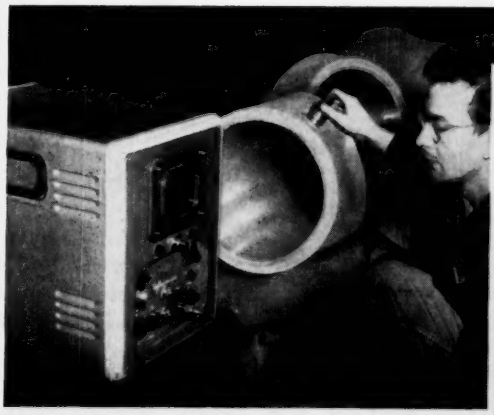
Special gauges and instruments are used to make sure that we have complied with the extremely close tolerances often required on stainless fittings. Here wall thickness and concentricity were held within extremely close limits throughout the fittings.

The exclusive Midwest method of manufacture—much more versatile and flexible than any other—enables us to make almost any type of special welding fittings to the most rigid specifications. Midwest makes welding fittings from *plate* . . . usually much easier to get than pipe, particularly if the material is special. That expedites delivery. Closer tolerances are inherent in the Midwest process, and quality control is always beyond code requirements.

Even if you use only standard fittings, the exceptional quality of Midwest fittings can be important to you. Ask your Midwest distributor or write us for new Bulletin 5801.



36" O.D. 90° elbow with 16" tangent on one end being welded by an automatic submerged arc machine. Material is A-201 carbon steel.



Stainless-clad elbows undergoing ultrasonic inspection to check bonding of material and quality of weld. Since plate is often the only form in which clad material is available, the Midwest process is able to produce the most comprehensive range of clad fittings—and to do so promptly.

Special 24" x 21" 45° reducing elbow made of 1" thick 1¼% chrome ½% moly steel ready for heat treating furnace.

MIDWEST PIPING COMPANY, INC.

Main Office: St. Louis 3, Mo. (P. O. Box 433)

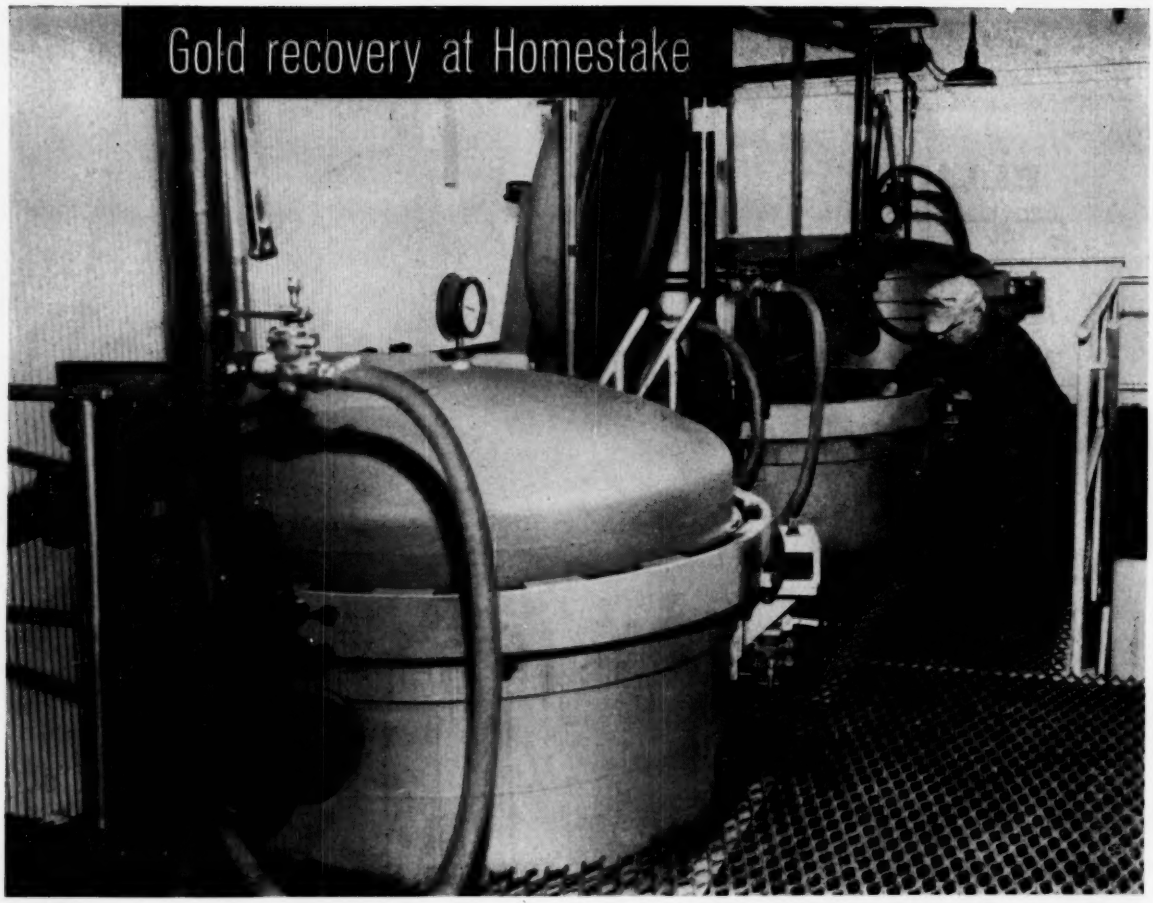
PLANTS: ST. LOUIS, CLIFTON, N. J. and LOS ANGELES

SALES OFFICES:

Asheville (Box 446, Skyland, N.C.) • Atlanta 9—72 11th N.E.
Boston 27—426 First St. • Chicago 3—79 West Monroe St.
Cleveland 14—616 St. Clair • Houston 2—1213 Capitol
Los Angeles 33—520 Anderson • Miami 34—2103 Le Jeune
New York 7—50 Church St. • Pittsburgh 19, Pa.—437 Grant
San Francisco 11—420 Market St.
St. Louis 4, Mo.—1450 South Second St.

STOCKING DISTRIBUTORS IN PRINCIPAL CITIES

8059



Process Filters help wring precious metal from stubborn ore

Tough and hard, the gold bearing rock of South Dakota clings stubbornly to the tiny particles of precious metal it contains. To extract gold from the ore, Homestake Mining Co., Lead, S. D., grinds the rock to a fine powder, then dissolves the rare metal with a solution of sodium cyanide.

After the ore slurry is passed through Merrill presses, the ongoing solution must be cleansed of all inert matter and residue before the gold is precipitated. Three Process Model V470-2 Filters do the job, clarifying the gold-bearing cyanide stream at better than 54,000 gallons per hour. Covered with Process Quick Change Bags, filter leaves are cleaned by newly-developed rotary sluicing headers which remove the cake rapidly and completely.

Says Homestake Mining Co., "Choice was made mainly on a filter with sufficient capacity to handle the job, yet small enough to fit into the area available . . . Process Filters' service has been satisfactory."

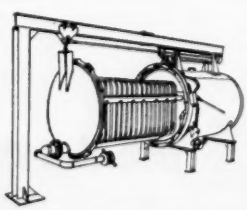
Combining rapid flow rates with proved dependability, Process Filters are raising performance standards throughout the chemical and petrochemical industries. Both standard and specially engineered units are available with a wide range of accessories to meet your process requirements.

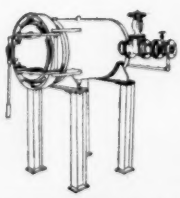
Detailed information on the types shown below is yours for the asking. Request one or more Bulletins listed.

PROCESS FILTERS, INC. *(A subsidiary of Bowser, Inc.)*
1807 Elmwood Ave., Buffalo 7, N. Y.

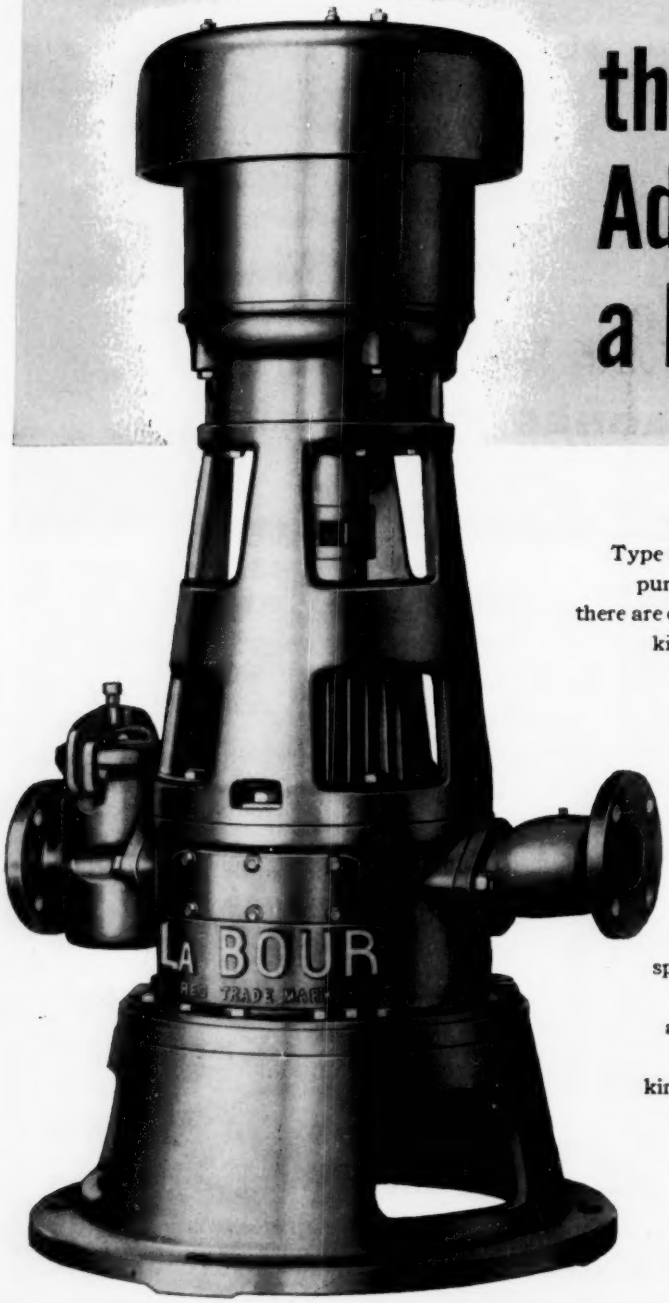

VERTICAL LEAF FILTERS
Bulletin V


VERTICAL BATCH FILTERS
Bulletin VBO


HORIZONTAL LEAF FILTERS
Bulletin H


HORIZONTAL BATCH FILTERS
Bulletin HB


CARTRIDGE FILTERS
Bulletin C



the OTHER Advantages of a Kinetic Seal

The obvious reason for choosing a LaBour Type G, the packingless self-priming centrifugal pump, is that it never has to be repacked. But there are other advantages resulting from the unique kinetic seal which should not be overlooked.

LaBour Type G is sealed by the *action* of a freely turning part, not by the part itself. Nothing in the kinetic seal rubs against anything else at any time—in fact, the clearances aren't even close. Because there is no packing there is no possibility of contaminating the product being pumped.

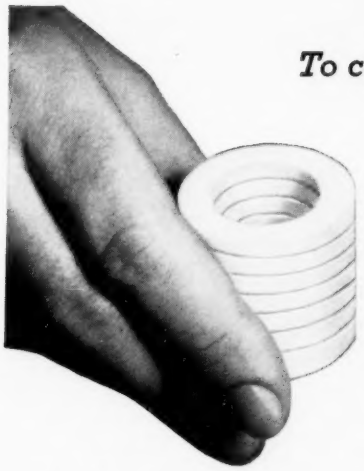
Visible leakage from a stuffing box can be spotted and corrected when it occurs, but in many situations the invisible leakage of air or gas *into* the liquid can be a source of great trouble and expense. The LaBour kinetic seal cannot deteriorate through wear, and cannot leak in either direction.

If you haven't considered *all* the advantages of LaBour Type G with its kinetic seal, it will pay you to write us for the complete story.

ORIGINAL MANUFACTURERS OF THE SELF PRIMING CENTRIFUGAL PUMP

LABOUR

THE LaBOUR COMPANY, INC. • ELKHART, INDIANA, U. S. A.



To combat chemical and solvent action . . .

Choose a J-M Teflon* Packing!

They're chemically inert . . . available immediately in the J-M Chempac® line

REPORTS from the field are the proof: you just can't beat J-M Teflon packings and gaskets for resistance to the constant attack of chemicals and solvents!

That's why we say . . . you'll find the answer to any corrosion problem in the J-M Chempac line . . . available in pure Teflon, or Teflon combined with asbestos. The latter construction offers the excellent sealing and heat resistance of asbestos, plus the added protection of Teflon against chemical and solvent action.

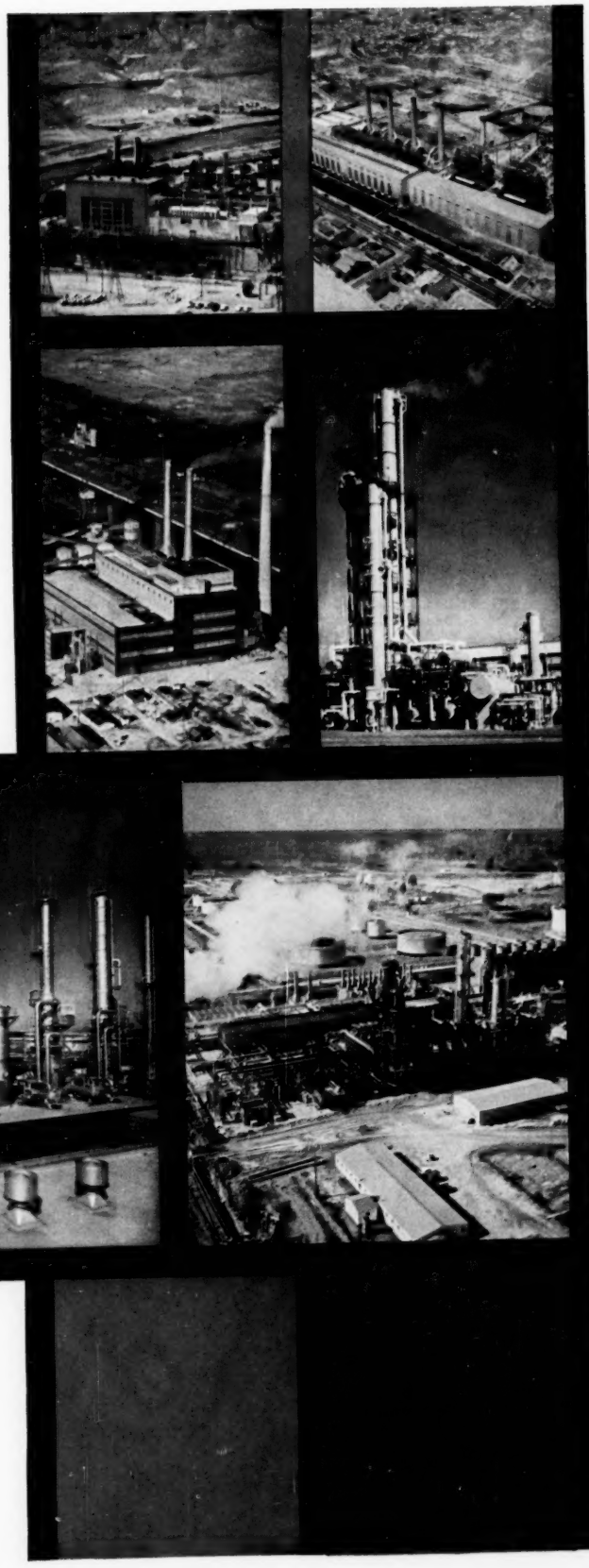
You'll find Chempac Teflon Packings in moulded and braided types for pumps and valves . . . in a wide range of flange and envelope-type gaskets . . . in rings, cups, sheets and tapes. Moreover, we can tailor-make packings, gaskets and precision-moulded parts to your exact specifications. Important, too, our new Teflon production facilities assure prompt delivery in any quantity you need.

Ask your Johns-Manville Packing Distributor to help you select the right Chempac Teflon Packing for your application—or write Johns-Manville, Box 14, New York 16, N. Y. In Canada, 565 Lakeshore Road East, Port Credit, Ontario. Ask for Brochure PK-124A.

*TM for Dupont Tetrafluorethylene resin

JOHNS-MANVILLE

9 bright new lights in the industrial world



Stone & Webster Engineering Corporation brings a world of experience to new projects and problems . . . all around our growing industrial globe.

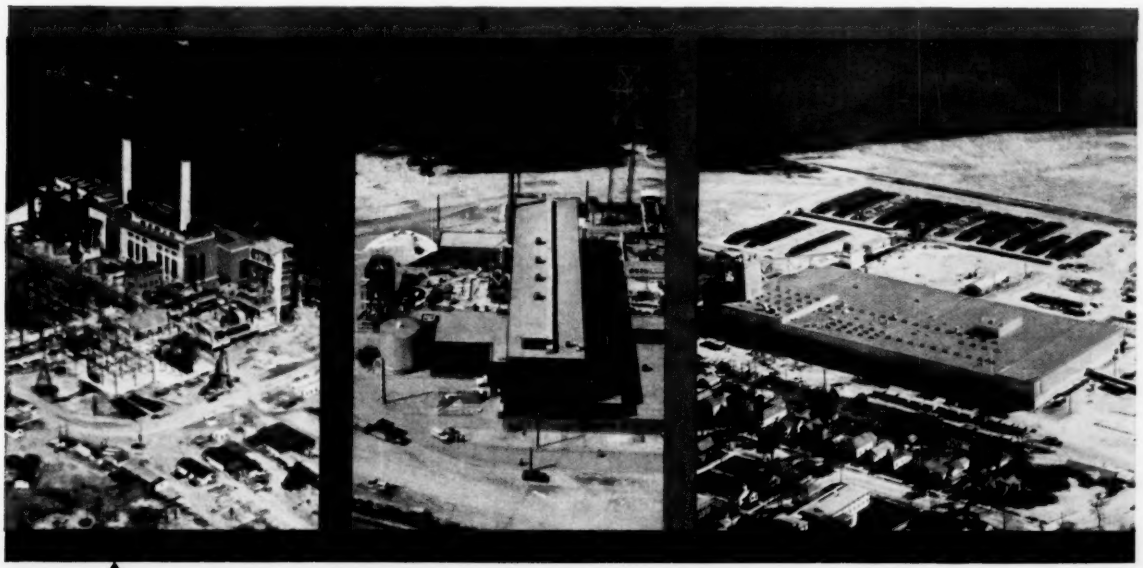
Steam and hydroelectric facilities, chemical plants, refineries, factories, breweries, hospitals, laboratories, pulp and paper mills . . . Stone & Webster takes pride in such continuing contributions to the world's industrial development.

Stone & Webster engineers can be found on many jobs . . . designing and constructing plants . . . developing special processes and equipment . . . helping business with appraisals, reports and consulting advice on a full range of financial and technical problems.

The successful application of Stone & Webster's varied engineering skills has reduced costs . . . construction and operating . . . for many clients in many fields . . . a big reason why 80% of our present work is for companies we have served before.

No matter what the magnitude or complexity of a project, Stone & Webster's integrated organization can produce the trained personnel to complete it . . . thoroughly, successfully, on schedule . . . anywhere in the world.

For further information write or call Stone & Webster Engineering Corporation at 90 Broad Street, New York City, or contact our nearest office.



STONE & WEBSTER

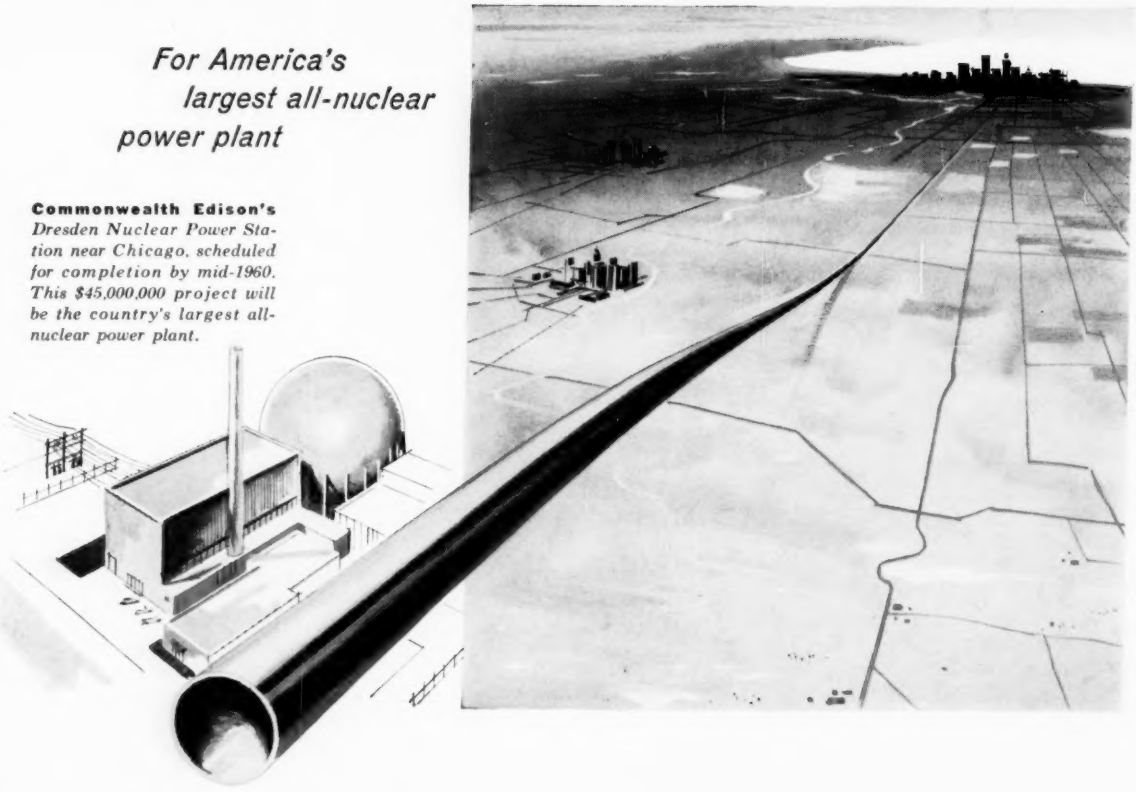
ENGINEERING CORPORATION

A SUBSIDIARY OF STONE & WEBSTER, INC.

New York Boston Chicago Pittsburgh Houston San Francisco Los Angeles Seattle Toronto

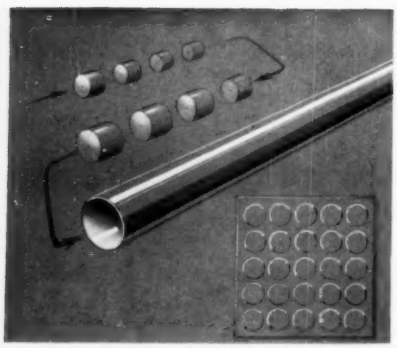
For America's largest all-nuclear power plant

Commonwealth Edison's *Dresden Nuclear Power Station near Chicago, scheduled for completion by mid-1960. This $45,000,000 project will be the country's largest all-nuclear power plant.*



44 MILES OF ZIRCONIUM TUBING

being processed by Mallory-Sharon



To form fuel rods, *cylindrical pellets of UO_2 are inserted in Zircaloy tubing. Tubes are sealed and welded, then assembled into "bundles" to form the rod-type element (inset).*

See our 4-page ad in Chemical Engineering Catalog, Pages 1147-1150, for additional technical information.

Here you see a striking example of zirconium's place in nuclear power . . . and of Mallory-Sharon's leadership in zirconium production and technology.

The largest order ever placed for zirconium tubing—almost 44 miles of it—is now being processed by Mallory-Sharon, in conjunction with Bridgeport Brass Co., for the Dresden Nuclear Reactor. Made of reactor-grade Zircaloy-2, 9/16" diameter and 1/32" wall thickness, the tubing must meet rigid tolerances . . . pass special pressure, sonic and corrosion tests. Fabrication of fuel elements is by the Atomic Power Equipment Dept. of General Electric, at San Jose, California, designers and builders of the Dresden Station for Commonwealth Edison.

As the largest integrated producer of zirconium, titanium and special metals, we invite you to write for information on either reactor-grade or commercial grade zirconium. Our Service Engineering group is ready to work with you *now* on either nuclear or commercial applications.

Write for new booklet, *"Technical and Application Data on Zirconium and Hafnium".*

MALLORY MS **SHARON**

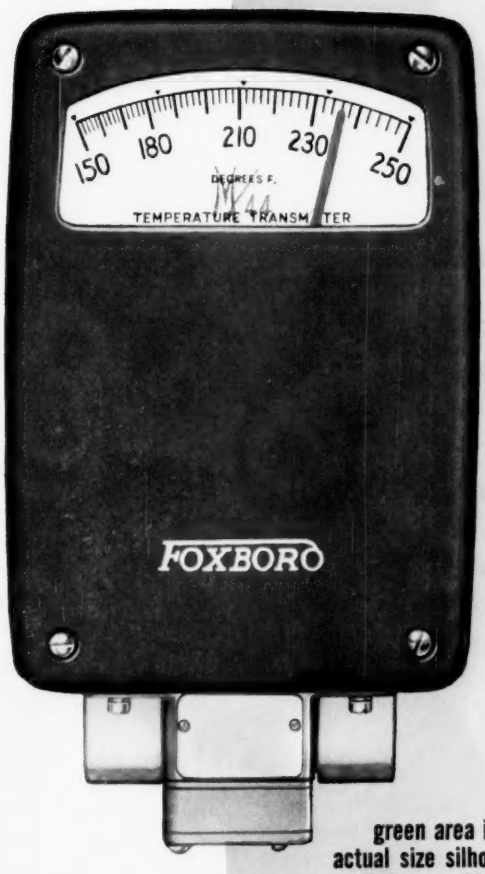
MALLORY-SHARON METALS CORPORATION • NILES, OHIO

Integrated producer of Titanium • Zirconium • Special Metals

a compact, low-cost

INDICATING TEMPERATURE TRANSMITTER

engineered for fast, sensitive response under roughest field conditions — uses any filled thermal system.



green area is actual size silhouette of the new M/44

Here's a brand new instrument engineered specifically for its job of indicating and transmitting temperature.

The M/44 Indicating Temperature Transmitter offers the inherent simplicity of a motion balance instrument. Compact and lightweight (10 lbs.) its indicating scale and fluorescent red pointer are visible up to 20 feet away. The output pressure of the M/44 is transmitted to any remote 3-15 psi recorder, controller, or indicator.

The M/44 is made with standard performance-proved Foxboro components, simply and conveniently arranged in a weather proof steel case. Changing range or type of thermal system can easily be done in your own plant.

Thanks to its rugged construction, the new M/44 is unaffected by vibration, sudden shock, or corrosive atmosphere. Even in the event of air supply failure, this instrument continues to indicate process temperature.

Ask your Foxboro Field Engineer about this new instrument. Or write for Bulletin 13-28A, The Foxboro Company, 366 Neponset Ave., Foxboro, Mass.

CHOICE OF THERMAL SYSTEMS

Foxboro M/44 Transmitters are available with any filled thermal system. These classes are suggested for particular range characteristics:

Class II Vapor Pressure (100° to 600°F)
Lowest cost, fastest response, highest sensitivity. Recommended for all installations within this range except when the measured temperature crosses ambient temperature.

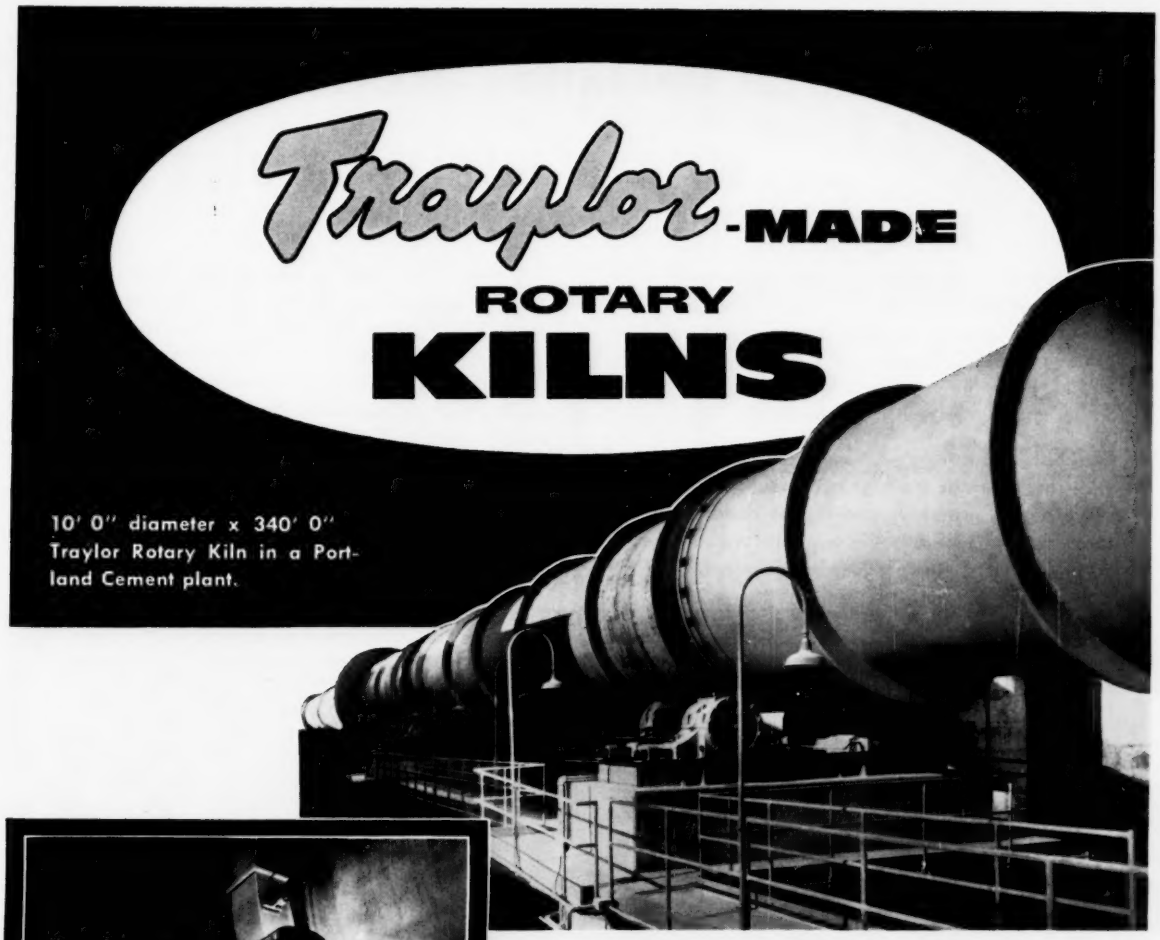
Class IA & IB Liquid Expansion (−250° to +600° F)
Good response, good sensitivity, uniform scale. Uses smallest bulb of any filled thermal system.

Class III Gas Pressure (−450° to +1000° F)
Applicable to ranges beyond the limits of other filled systems. Uniform scale. Bulb has long sensitive section; permits useful averaging measurements.

FOXBORO
REG. U.S. PAT. OFF

TEMPERATURE MEASUREMENT AND CONTROL

Traylor-MADE ROTARY KILNS



10' 0" diameter x 340' 0" Traylor Rotary Kiln in a Portland Cement plant.

Auxiliary drive on a 7' 0" diameter x 250' 0" Traylor Rotary Kiln in a paper mill.

Traylor-made machinery — a name that reflects quality and craftmanship to all that know the heavy machinery field. Traylor Rotary Kilns are an example of sound design and rugged dependability. Traylor Kiln Shells are fabricated of quality steel plate. The main gear of a rotary kiln is made in halves and usually of cast steel, and is part of the gear train which includes the main pinion of cast, forged or tool steel with low addendum machine-generated teeth. An adjustable base is recommended under the complete driving mechanism unit. There are many more features of the Traylor Rotary Kiln which you can obtain by writing for bulletin #1115 for complete information.

Traylor

TRAYLOR ENGINEERING & MFG. CO. 1050 MILL ST., ALLENTOWN, PA.

Sales Offices: New York — Chicago — San Francisco

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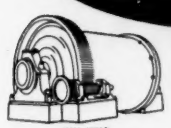
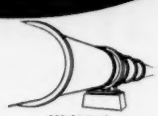
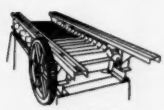


BALL MILLS



ROTARY KILNS



APRON FEEDERS

PRIMARY GYRATORY CRUSHERS

JAW CRUSHERS

SECONDARY GYRATORY CRUSHERS

IN PRESSURE OR VACUUM DISTILLATION METAL PALL RINGS PROVIDE MAXIMUM SEPARATION—MAXIMUM CAPACITY

. . . with a minimum size shell

The superiority of metal Pall Rings is nowhere more clearly established than in distillation operations. Here two characteristic advantages of the Pall Ring come into play: (1) extremely low pressure drop, and (2) exceptional internal distribution at the low liquid rates employed in distillation.

In bubble cap towers or distillation columns packed with raschig rings the higher pressure drops necessitate higher pressures and higher boiler temperatures. Not infrequently the temperature required is so high as to invite product break down.

Not only can lower pressures and lower boiler temperatures be employed when the column is packed with metal Pall Rings but the fractionating efficiency of the column can be improved as much as 25% to 40%. In new construction the higher efficiency of the metal Pall Ring permits substantially smaller shells to be employed.

Metal Pall Rings are now being made in the ⅝", 1", 1½" and 2" sizes from carbon steel, the 18-8 series of stainless steels, monel, inconel, titanium, aluminum and copper.

The metal Pall Ring is similar to the raschig ring in that height and diameter are equal. In the raschig ring the interior wall is mostly inactive providing little or no active contact between phases. In the metal Pall Ring, sections of the wall are stamped and bent inward, thus making the inner wall an active, working surface. Pressure drop is less than half that of raschig rings, resulting in a much greater capacity per unit of tower area.

Write today for engineering data on metal Pall Rings.

U. S. STONEWARE

AKRON 9, OHIO

224-F

Chemical Engineering

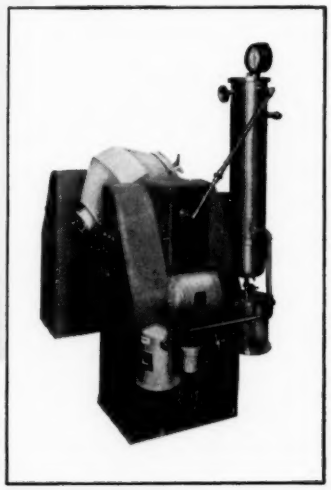
Developments

JUNE 2, 1958

Department Index

Completely integrated vacuum drying system using P-K Vacuum Tumbler Dryer Blender.

Side view, showing vacuum pump, condenser and related components. Note compact arrangement and short lengths of piping.



The P-K Vacuum Tumbler Dryer

A faster, better way to vacuum-dry heat sensitive materials

The remarkably fast drying action of the P-K Vacuum Tumbler Dryer—a fraction of the time required by conventional methods—is partly accomplished by baffling in the jacket, which circulates the heating medium uniformly around the containing vessel. In addition, rapid generation of vapors produces a scrubbing action on the walls of the blender, improving the heat transfer rate to a marked degree.

These factors, important as they are, do not tell the whole story. The P-K Dryer operates at optimum efficiency when it is part of a completely integrated, factory engineered system, instead of an on-site assembly of component parts and piping—which increases the cost and impairs the attainable benefits. For heat senstive material drying, in a closed system, there must be a perfect balance of jacket circulation, vapor filter, vapor line, *compact* piping, vacuum line, vacuum pump and effective controls.

These essential relationships P-K provides, including factory designed supports to house the entire operation. The illustrations show a unit used in P-K's Customer Service Laboratory to pre-test the specific requirements of your formulae. You are urged to use this service without cost or obligation. Similar integrated units can be designed for your needs in capacities from 1 to 150 cubic feet.

Use the coupon to secure Data Sheet No. 1530. Better yet, contact our Customer Pre-test Department for a test if your heat sensitive formulations are difficult to produce rapidly, satisfactorily—and economically.

Patterson Kelley

Chemical and Process Division

Executive offices and plant: East Stroudsburg, Pa.

P-K "Twin Shell" Blenders • Heat Exchangers • Packaged Pilot Plants • P-K Lever-Lock Doors • P-K Cone and Ribbon Blenders

Patterson-Kelley Co., Inc.
1506 Hanson Street
East Stroudsburg, Pa.

Send me the information on vacuum drying checked below:

☐ Data Sheet No. 1530
☐ P-K pre-test of our product

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*Company*_____

*Street Address*_____

*City*_____ *Zone*____ *State*_____

DEVELOPMENTS . . .

JUNE 2, 1958

Chementator

C. H. CHILTON

Cyanamid has a new process in which naphthalene is oxidized to produce anthraquinone and naphthoquinone instead of phthalic anhydride. Process will go commercial at Bound Brook plant.

Submerged combustion has secured a strong foothold in the field of organic waste treatment. Chemstrand runs adipic acid waste through a tank heated by submerged combustion; COD is reduced by 50-75%.

Artificial cryolite plant will be built at Garfield, Utah, by United Heckathorn, Inc. Using a new process, plant will reclaim fluorine from phosphoric acid circuit of Western Phosphates.

Court holds trade secrets sacrosanct

A judge's decision in U. S. District Court of Utah late in April carries far-reaching implications for every chemical engineer.

In the case of Monsanto Chemical Co. vs. Charles M. Miller, a former Monsanto employee, and F. C. Torkelson Co., Salt Lake City engineering firm, the court upheld Monsanto's employee contract which forever forbids Monsanto employees from disclosing or using Monsanto's trade secrets and confidential know-how. Even information acquired via observation and conversation, whether carried in the mind or on paper, is included.

Miller was a Monsanto employee from 1942 to 1954, during which time he became intimately acquainted with Monsanto's techniques for making elemental phosphorus. He subsequently joined Central Farmers Fertilizer Co. and has consulted with Torkelson in the engineering of a phosphorus plant for CFF at Georgetown, Idaho.

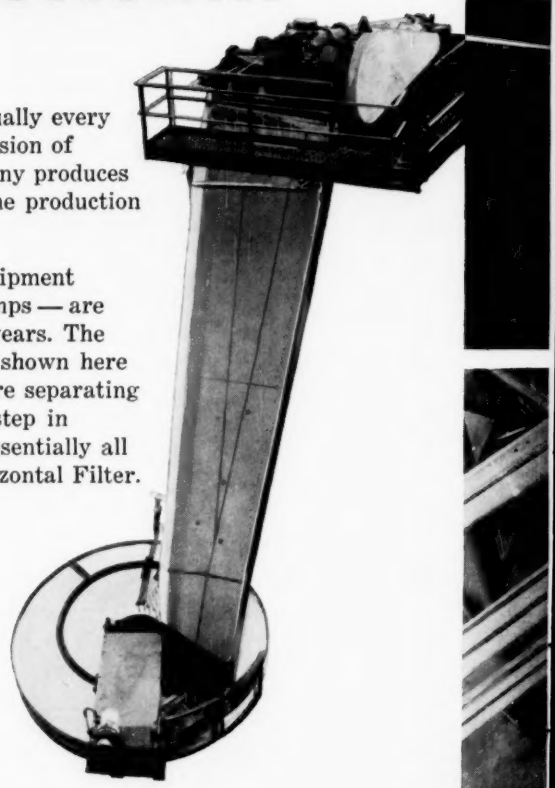
As far as Monsanto is concerned, the decision of Judge A. S. Christenson means that Miller cannot participate in any venture in which he would reveal or use Monsanto trade secrets. Nor can Torkelson build or put on stream any plant using Monsanto trade secrets; Torkelson has issued a statement affirming this conclusion. Monsanto is pretty certain to press for damages against Torkelson and Miller, although exactly what damages will be sought is not yet clear.

What does this decision mean to the chemical engineer? Although the Utah trial covered many legal issues, key point in the case, as far as the engineering profession is concerned, was whether an employer could under common law forever require an engineer or scientist to keep secret certain knowledge gained in the course of his employment.

The judge's decision apparently establishes trade secrets as a matter of common law. This means that, even without an employment contract, unauthorized use of trade secrets

(Continued on page 46)

HERE'S HOW WEST END GETS TONNAGE CHEMICAL PRODUCTION...



Dorr-Oliver equipment and techniques are used in virtually every wet processing step at this giant chemical plant. A division of Stauffer Chemical Company, West End Chemical Company produces soda ash, salt cake, borax and hydrated lime used in the production of paper, glass and other products.

At their West End, California plant, over forty D-O equipment units — Agitators, Classifiers, Filters, Thickeners, Pumps — are operating around the clock... some for as long as 20 years. The Dorr Classifier — Oliver Horizontal Filter combination shown here is a typical team for tonnage production. These units are separating and washing Glaubers salt from mother liquor, a key step in West End's unique flowsheet. Classifier rake product, essentially all +30 mesh, is discharged by chute directly onto the Horizontal Filter. Feed to the Oliver contains about 80% solids while cake is discharged at 3-4% moisture. Still more important, the stainless steel Horizontal shows a wash efficiency of plus 95% while handling 350 TPD!

For the Process Industries, Dorr-Oliver offers a complete and integrated service from lab testing through complete plant design and construction. If you want to know more about D-O equipment and techniques, write for a copy of Bulletin No. 7003. Dorr-Oliver Incorporated, Stamford, Connecticut.

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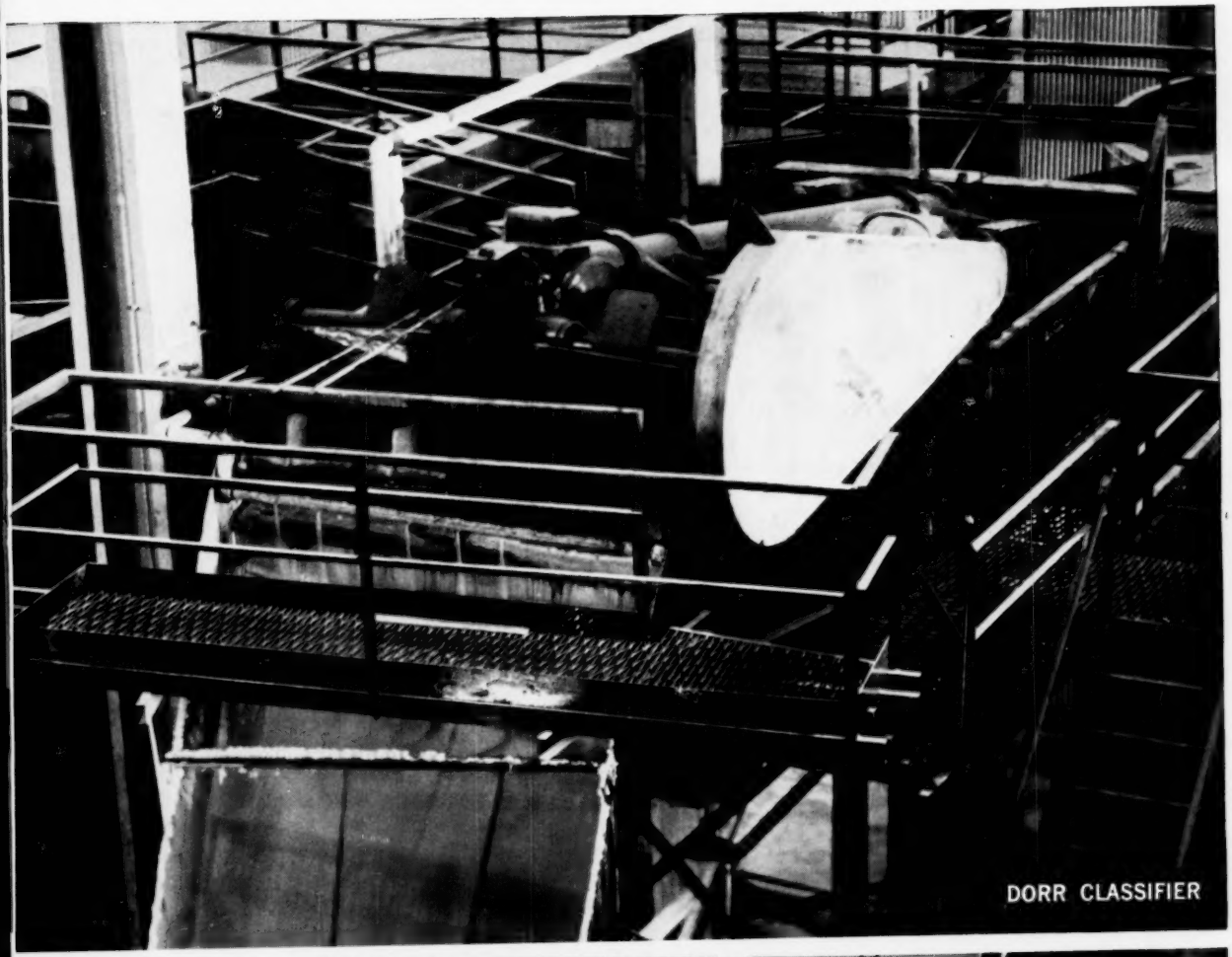


DORR CLASSIFIER

OLIVER HORIZONTAL FILTER

is just as wrong as misappropriation of money or any other private property.

What will happen to CFF and its new phosphorus plant? That will be decided via a separate suit against CFF in Pocatello, Idaho, which has not yet come to trial.

Hastelloy B keys new process success

Conversion of a fixed-bed catalytic process to fluid bed is not of itself unusual these days. Novel twist in California Research Corp.'s new fluid process for polymerizing olefins into motor gasoline is that the catalyst is—and always was—a liquid, namely phosphoric acid.

In conventional fixed-bed cat poly processes, the acid is coated or impregnated on solid support materials. In the new process, the acid circulates through the perforated-plate reactor in bulk liquid form, with these reported results: Smaller reactor per unit of output; higher economical conversions; easy catalyst replacement; good temperature control.

Humble Oil is known to have worked on a similar process but presumably never carried it past the laboratory stage. Cal Research has pushed its process through a 100-bbl./day demonstration plant at Richmond, Calif.

Key to successful operation is use of Hastelloy B, a nickel-molybdenum alloy. Although stainless steel is suitable in the fixed-bed process, continuous circulation of acid over the reactor walls in the new process aggravates the corrosion problem. (Environmental conditions are roughly the same in both processes: Temperature, 300-400 F.; acid strength, 98-106%; pressure, 800-1,200 psi.) Recent development of Hastelloy B-clad steel will help reduce cost of large-scale process equipment.

Pump and valves handling phosphoric acid are also made of Hastelloy B. Pump seals and valve trim, however, are made of other materials which Cal Research won't identify.

Rubber makers endorse new technique

New-found ways to put carbon black into styrene-butadiene rubber at the latex stage without need for dispersing agents has set off a round of new construction in the rubber industry. General Tire & Rubber led off the parade with a 150-million-lb./yr. carbon black masterbatch plant started up this month (see flowsheet, pp. 102-5).

Goodrich-Gulf is putting in a $1-million unit for carbon black masterbatch at Port Neches, Tex. Copolymer Corp., Baton Rouge, and Texas-U. S. Chemical, Port Neches, have recently announced plans for similar plants.

With one or two exceptions, all major rubber makers are apparently on the verge of following suit.

Newly improved techniques, such as that developed by Columbian Carbon (*Chem. Eng.*, July 1957, p. 164), result in greater tread strength in tires. Dispersing agents used in old masterbatch processes tied up some of the carbon black so that it did not fully function as a reinforcing agent.

Almost all major rubber manufacturers are Columbian licensees. While their commercial plants may incorporate substantial amounts of their own development work, they all—like Columbian—take a continuous, no-dispersing-agent approach.

Getting rough solved this problem

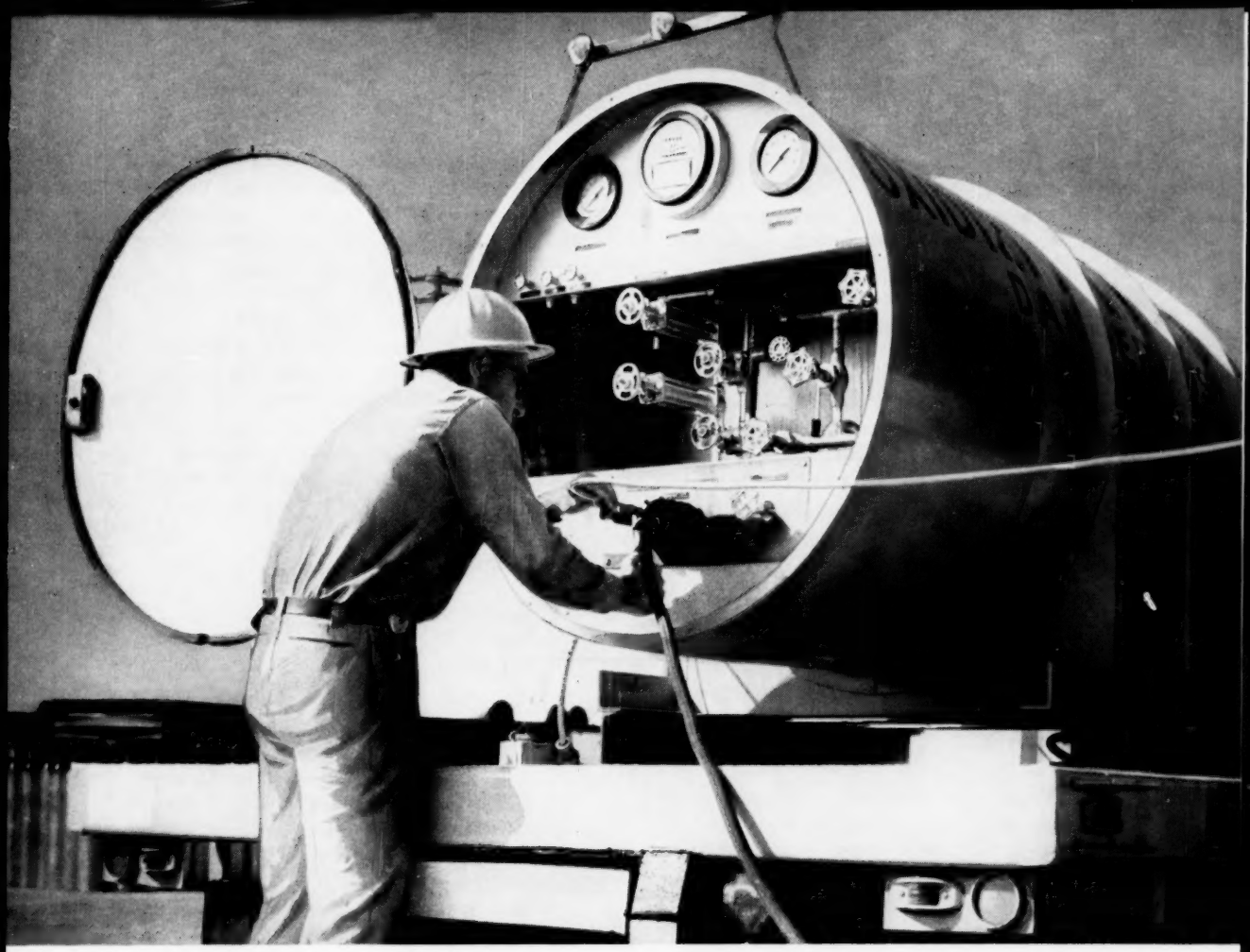
For an unconventional solution to a sticky problem, that offered by George Schneider of Fuller Co.'s Dracco division takes the cake.

In order to prevent the smearing or ribboning of polyethylene pellets on the inside surfaces of pneumatic conveying systems, Schneider proposed that the pipe walls be roughened by sandblasting, rather than the more logical procedure of making them smoother. It worked—so well, in fact, that upon recent issuance of Schneider's patent (U. S. 2,784,038) Dracco revealed to *CE* that nearly a dozen polyethylene producers and consumers are already using the idea.

Dracco engineers claim that from the standpoints of cleanliness, economy and convenience, pneumatic conveying is the nearly ideal way to handle polyethylene pellets or flakes in bulk. With ordinary metallic piping, however, particles tend to smear on the inside wall and agglomerate into lumps which clog feeders, valves and other process equipment. When Dracco found that plastic or glass piping, with their smoother surfaces, were just as bad as metals, Schneider put forth the sandblasting idea.

The improved conveying system was first applied commercially over two years ago by Western Electric. Success here led to its adoption by such leading polyethylene producers as Phillips and Celanese.

(Continued on page 48)



TAMED: *the elemental fury of fluorine!*

Still thinking of elemental fluorine as "too hard to handle"? Not any more! As a result of General Chemical research, this "optimum" oxidizer can now be stored, transported and handled directly *as a liquid* in tank-truck tonnages. If you are interested in working with fluorine as an oxidizer for rocket fuels, or for any other application, this development could be of major importance to you.

Benefits of liquid fluorine. Now that fluorine is available in liquid form and in bulk quantities, you can handle and store it more easily, more safely and more economically than ever before. An important *plus* value—the shipping containers can also be used as storage tanks.

Halogen fluorides also available. The halogen fluorides, too, are commercially available from General Chemical. Chlorine trifluoride is available in ton cylinders and cylinders of 150 lbs. net. Bromine trifluoride, bromine pentafluoride and iodine pentafluoride are offered in various-sized cylinders to suit demand.

Write for free technical bulletins. A comprehensive new technical bulletin, "Fluorine," will be sent you on request. Also Technical Bulletin TA-8532-2, covering Chlorine Trifluoride and other Halogen Fluorides. Write for your free copies today.

Allied Chemical

First in Fluorine Chemistry

GENERAL CHEMICAL DIVISION

40 Rector Street, New York 6, N. Y.

Sandblasting the inside of small pipes can be difficult. Although Dracco has developed techniques for treating pipes as small as 1½ in., most commercial installations use lines of 3 in. IPS or larger.

Moving expenses are not deductible

Money paid new employees to reimburse them for expenses in moving to their new job is taxable after all, according to the latest court decision. Upon appeal of the Internal Revenue Service, 10th Circuit Court of Appeals in Denver overruled last month an earlier decision of U. S. District Court in Albuquerque (*Chem. Eng.*, Feb. 10, 1958, p. 163).

The court held that travel expenses for new hires are not deductible as a business expense. In the opinion of Judge John J. Pickett, "The payment [of moving expenses] was in the nature of a cash bonus as an inducement to accept employment. . . . The expenditure had no relation to any service which was being performed for the employer."

Case involved two employees of Sandia Corp., an AEC contractor at Albuquerque. These two were selected from among 300 Sandia employees for the court test.

Sandia's recruitment policy allowed new employees the cost of moving 7,500 lb. of household goods, hotel and meals en route and 6¢/mi. automobile travel. New workers received the payments upon the condition that they remain with Sandia at least six months.

Iron process merges kiln, arc furnace

Realistic economic appraisal by Koppers' Engineering Div. of the Strategic-Udy direct iron process prescribes well-defined limitations as to where the new process might expect to compete successfully with blast furnace-coke oven methods of making pig iron.

According to Koppers, the Udy process is competitive with capacities of less than 1,000 tons/day and in areas where cheap power, good iron ore and noncoking or poorly coking coals are available. There are many such areas of the world today, says Koppers.

In the new process, iron ore, limestone and soft coal are processed at 1,850 F. in a rotary kiln, then discharged hot into a submerged-arc furnace. More coal is added to complete the reduction. Product can be either a 3.5%-carbon pig iron or 0.5% C semisteel.

Economics of the process—tested last fall in a prototype plant at Niagara Falls, Ont.—depend a great deal on optimum balance of prereduction kiln and electric furnace. The more prereduction obtainable in the kiln without running into handling problems, the less the power load on the electric furnace.

In the prototype run, the 80-ft.-long rotary kiln achieved only 30% prereduction, leaving a load for the 1,000-kva. arc furnace of 1,800 kwh./ton pig iron. With a kiln designed specifically for 70-80% prereduction, Koppers estimates that power consumption would be only 1,250 kwh./ton.

MSG by fermentation or synthesis?

Merck's announcement that it is entering monosodium glutamate production via a $4.5-million unit at Danville, Pa., is the first decisive move to come out of recent jockeying for position among present and prospective producers of this flavor-enhancing chemical.

For its route to MSG, Merck has licensed a fermentation process from Kyowa Fermentation Industry, a Japanese MSG producer. Merck will start with sugar; Kyowa starts with sweet potatoes.

Within recent months, both Du Pont and International Minerals have announced processes for total synthesis of MSG. A Du Pont patent (U. S. 2,801,250) describes oxidation of 3-aminocyclopentene to glutamic acid. Another potential starting material is furfural. Quaker Oats considered a furfural-based Japanese process but has decided that it is not yet ready for commercialization.

On the fermentation front, both Pfizer and Rohm & Haas have patented MSG processes. Pfizer (Brit. 776,722) starts with alpha-ketoglutaric acid and urea; R&H (U. S. 2,798,-839) starts with citric acid and ammonia.

Most commercial processes to date have been based on chemical isolation of MSG from natural products, e.g., beet-sugar waste, wheat or corn gluten (*Chem. Eng.*, Nov. 1955, pp. 126-8). The L(+) form of glutamic acid, from which the desired flavorful form of the monosodium salt is easily made, occurs naturally. Fermentation processes also produce the L form. Organic syntheses, on the other hand, yield a racemic mixture which poses problems. Presumably Du Pont and IMC have found ways around these problems.

For more on DEVELOPMENTS.....50

PROCESSES & TECHNOLOGY

C. S. CRONAN

Splitting by Permeation Boasts Commercial Worth

Crowning several years of research and development, researchers at American Oil Co., Texas City, Tex., have come up with a commercially promising process — liquid-phase permeation—to separate chemical and petroleum mixtures.

Many close-boiling, wide-boiling and azeotropic mixtures can be split, reports American, and in some cases much more cheaply than by simple distillation or solvent extraction. Chief reason for favorable economics is simplicity of equipment; main item is a film holder containing nonporous polymer film. Film divides the holder into two compartments.

▶**Works Via Solubility** — Permeation process functions neither by molecular sieving action nor by Graham diffusion. It depends on preferential solubility of various components in a mixture. Solubility and molecular structure are the important properties in permeation techniques.

Process works this way. Liquid mixture feeds into one compartment of the film holder, maintained at a pressure equal to the vapor pressure of the mixture. Preferentially soluble component permeates through the film into the other compartment which is held at a low enough pressure so permeate is vaporized. A one-stage permeation unit can separate 80-90% pure material from a 50-50 mixture. Separated components are drawn off continuously.

▶**Commercial Potential**—In one example of commercial interest, American compared costs for splitting overhead from an alcohol distillation column, a ternary isopropanol-ethanol-water azeotrope. Compared are the alternatives of one-stage permeation and two-tower azeotropic distillation using hexane for entrainment.

Total unit cost (based on 10,470 lb./day crude isopropanol feed, dry basis) for permeation and azeotroping is 1.36¢/lb. and 1.68¢/lb., respectively. Biggest savings are in capital costs (permeation—$23,400, azeotroping—$30,800), maintenance, utilities and hexane loss.

Since the purpose here is to remove water impurities, water-rich permeate would be reinjected to distilling tower to prevent loss of alcohol which might permeate with water.

For this example, film area is about 650 sq. ft. and permeation cell with auxiliary equipment would fit into a space about 8 ft. long, 6 ft. wide and 6 ft. high.

New Multijet Flare Tames Smoky Flames

Results of more than a year's successful commercial operation have proven out a new multijet burner design as an effective way to combat undesirable smoke and light from safety flares.

Flare, developed by Esso Research, has been in service since late 1956 at the Halifax, Nova Scotia, refinery of Imperial Oil Limited. So promising are the results that Esso Research is now designing multijets for other Jersey Standard affiliates.

Key problem to overcome was that of mixing enough air with waste refinery gas at a fast enough rate to minimize carbon formation, and to burn carbon that is formed before it can agglomerate to form soot.

▶**"Flameholders" Are Key** — Burner assembly consists of 5-in.-long jets which discharge vertically from burner lines, or subheaders, running horizontally across the bottom of a stack. Most important feature, though, are "flameholders": solid, 1-in.-dia. rods of silicon carbide placed parallel to, and above, each burner line. Rods are positioned directly over the jet nozzle, with the bottom of the rod ½ in. above the tip of the nozzle.

These rods provide a surface at which the flame can burn, prevent it from riding up to the top of the stack. Too, they promote better mixing of air and gas, hence better burning.

Total cost of multijet flare, says Esso Research is $148,000, compared with $291,000 for elevated flare plus independent steam supply.

New Tire-Cure Process Promises More Mileage

A new method of processing nylon-cord tires, says U. S. Rubber Co., can give treads more mileage, better traction and more skid resistance.

Known as pressure tempering, the process is essentially a technique for taking the stretch out of nylon tire cord and rubber compounds. It's done by inflating the tire on a specially designed wheel immediately after tire is taken from vulcanizing mold. Tire is kept inflated at high pressure while it continues to cool and cure.

U. S. Rubber engineers explain that inflating the tire while it's hot removes internal stresses, allows cure to be completed with all parts of the tire in exact configuration that they occupy in service.

U. S. Rubber is now using pressure tempering on its entire line of nylon passenger tires.

Rotary-Kiln Reactor Uses Powdered Graphite

Newly patented in Germany, and already attracting wide interest among nuclear firms, a newly patented nuclear reactor (DBP 1,010,203) uses finely powdered graphite both as moderator and coolant, is similar to rotary kiln in construction.

Graphite, moved by a flights arrangement in rotating reactor walls, carries heat from fixed fuel elements to the walls. Explains inventor F. A. Henglein, director of Institute of Chemical Technics at Karlsruhe Technical University, reactor activity is controlled by varying amount of graphite in the reactor; fluidized graphite can be put in while reactor is in operation.

BRINE from Murphy Corp. oil field flows to pond which feeds Michigan Chemical Co.'s bromine recovery plant.

New Bromine Plant Taps Rich Oil-Field Brine

Two-year search and negotiation gives South new bromine facility producing for general market. Drive for new markets is key part of project.

Now approaching a full year's operation at its El Dorado, Ark., bromine plant, Michigan Chemical Corp. discloses, for the first time, the story of this new production source of bromine.

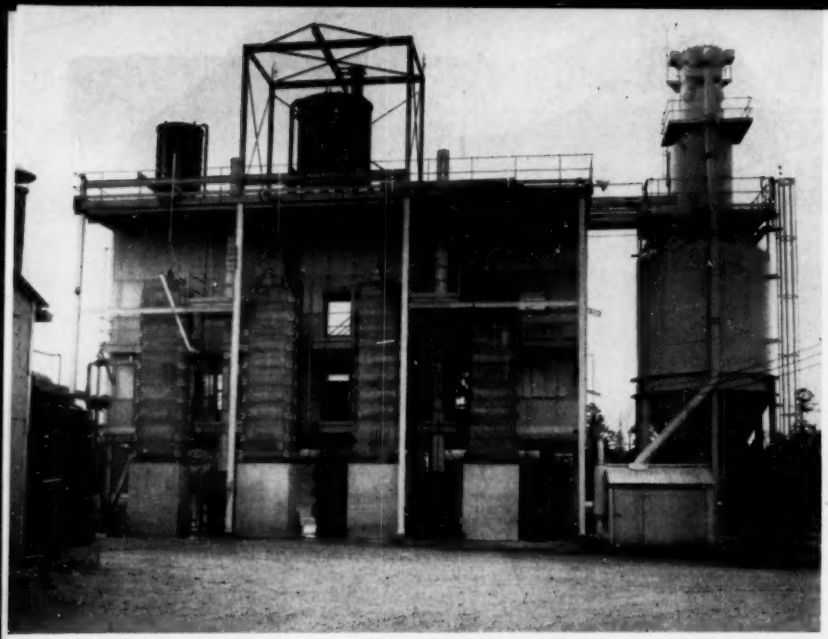
When Michigan Chemical started up this new bromine facility in April, '57, much of U. S. bromine output was flowing into captive markets such as production of tetraethyl lead. While bromine was available from several producers, there didn't seem to be market demand large enough or diversified enough to "spark" another independent manufacturing facility.

Yet, Pres. Theodore Marvin and his management team at Michigan Chemical have succeeded in opening a new source of supply and are developing new markets for their product. How have they been able to do it?

▶**Make It, We'll Sell It**—Reduced to simplest terms, Michigan's new philosophy is, "Tell industry we have a steady uncommitted supply of bromine at tonnage prices—they'll buy it." Back of this thought is the firm belief that industry's knowledge of the impressive properties of bromine should be expanded, and, when these advantages are recognized, they should open broad new markets, —providing additional supplies become available.

Proceeding on this premise, Michigan sought out and developed a completely new source of bromine. Michigan's disclosure that this new 5-million-lb./yr. source at El Dorado will reach a satisfactory output level in 1958 attests that Michigan's sales force is creating the expected new awareness of bromine's undeveloped potential as a chemical building block. And Michigan expects to be able to expand El Dorado further to service its future broadening market.

▶**Why Not Michigan Brine?**—Although Michigan Chemical



CHLORINE contacts brine in Kubierschky towers to liberate bromine.

Corp. has produced chemicals from Michigan state brine for many years at its home plants in St. Louis and Manistee, the company desired a different geographical location for its new producing facility.

Studying alternate producing areas, Michigan pinpointed the rich brine existing in the Reynolds zone of limestone in the Smackover oil field of southern Arkansas. Over two years of search and negotiations were required to combine at one plant site the factors of power, gas, railroad, highways, brine quality, and isolation from interference wtih other oil-producing areas. An agreement then was concluded with Murphy Corp. that it would gather and separate brine in conjunction with its production of oil in its field south of El Dorado.

Murphy supplies brine to the plant which is owned jointly by Murphy and Michigan, but is operated by Michigan. The two companies share equally in all economic phases of the operation with Murphy handling the difficult problem of payment of royalties to the oil lease holders.

▶**Twice as Rich**—Murphy's brine contains 4,200 ppm. of bromine, twice the bromine content of brines normally used for recovery, and from 65 to 70 times as rich as sea water. Absence of water flooding in the area assures continuation of this richness.

Through network of cement-asbestos pipes, brine flows into a central tank battery where residual oil floats off the brine. Outflow of brine from separator tanks discharges into an 800,000 gal. storage pond lined with an asphalt membrane to prevent seepage.

▶**Strip, Heat, Extract**—From the storage pond, brine is pumped through brush-packed wooden towers to remove small amounts of hydrogen sulfide or other dissolved gases. Leaving the towers through Haveg lines, brine picks up heat in exchangers from counterflowing tail brine, then passes to an overhead Monel gravity feed tank for the four Kubierschky extraction towers.

Flowing down through the ceramic and porcelain plate packing in these granite towers, brine contacts upflowing steam and chlorine which liberate bromine vapor from the brine.

▶**Condense, Separate, Purify**—Bromine and water vapor together with traces of chlorine go through glass lines to tantalum condensers and then into glass gravity separators for removal of water. Then, the bromine is fractionated in small ceramic towers to remove all traces of chlorine.

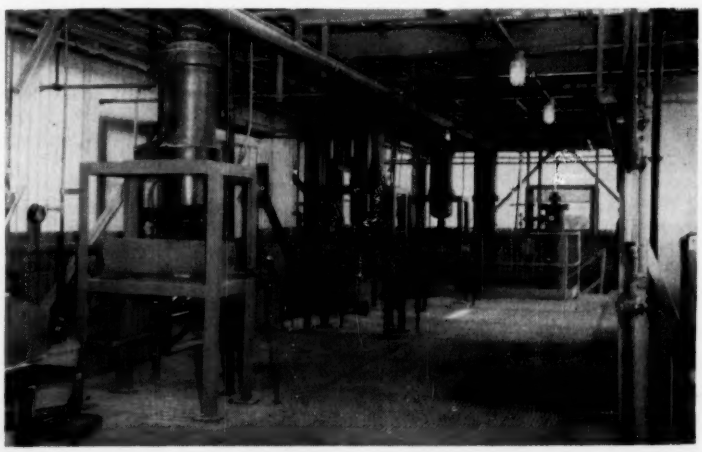
Chlorine-free bromine goes through a glass-lined distillation column for separation of non-volatile materials. Condensed bromine vapor from the distillation column contacts sulfuric acid in a packed, glass-lined column to remove last traces of moisture.

Moisture-free product is held in batch tanks until completion of sample analysis, then is transferred to storage tanks. Present capacity of these tanks totals 200,000 lb.

From storage, Michigan provides delivery in 30- or 50-ton lead-lined tank cars, 7½-ton tank trucks, 225-lb. drums or 6½-lb. bottles.

Following extraction, spent brine is limed, cooled, treated with chemical and settled prior to injection into a relatively shallow ground formation.

FRACTIONATORS (foreground) remove Cl_2, tower (background) dries Br_2.



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Medium pressures and temperatures—Series 60. Normal condensate loads, pressures 10 to 400 psi, temperatures to 450° F. Six sizes, ½" to 2".

HIGHER PRESSURES AND TEMPERATURES

Normal condensate loads—Series 120; pressures 10 to 600 psi, temperatures to 750° F. Six sizes, ½" to 2".

FOR LIGHT CONDENSATE LOADS

Medium pressures and temperatures—½" No. 20-A; pressures 10 to 400 psi, temperatures to 450° F.

Higher pressures and temperatures—½" No. 120-A (not shown); pressures 10 to 600 psi, temperatures to 750° F.

FOR HEAVY CONDENSATE LOADS

Low, medium and higher pressures and temperatures—Series 40 (lever type); pressures to 600 psi, temperatures to 750° F. Five sizes, ½" to 2½".

FOR POWER PLANT AND MARINE SERVICE

Integral-strainer trap. Normal capacities, pressures to 2500 psi. Six sizes, ½" to 2". Flanged or socket-weld ends.

Already more than 1,225,000 Yarway Impulse Steam Traps have been sold.

For your convenience—Yarway Traps and Strainers are carried in stock by over 270 industrial distributors all over the world. (Write us for name of the one nearest you.) Try some Yarways in *your* plant and begin to enjoy the improved trap performance many others are experiencing. Prompt steam trap engineering advice and service available to you from our own force of 34 field engineers.

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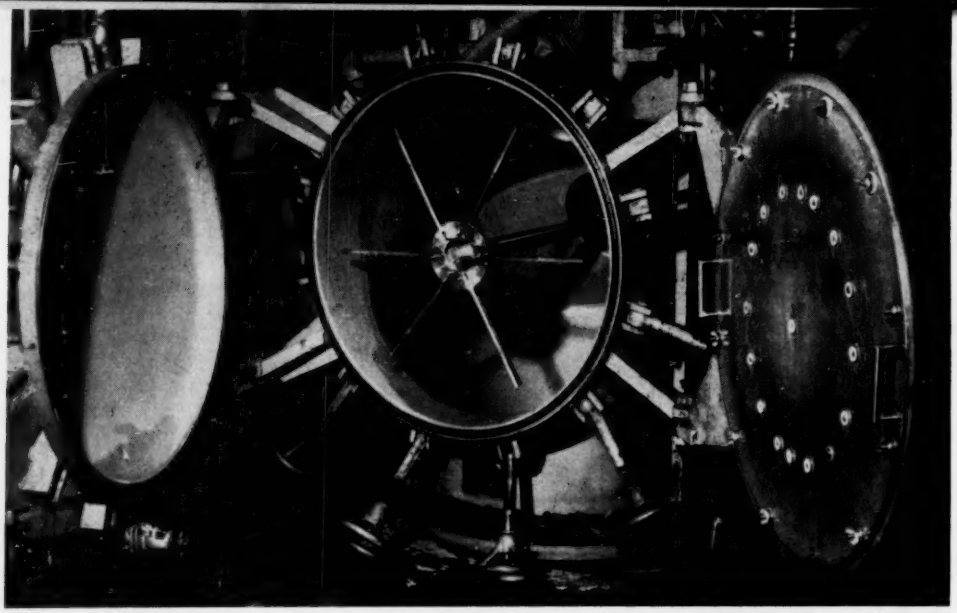


OPEN COVER (left) reveals turbine impeller (center) and resin-retaining screen (right).

Drug Maker Runs Ion Column on Thick Broth

Modified column opens way to use of column ion exchange on thick pulps without plugging and stoppage. Eliminating filtration, it boosts yields, saves many dollars.

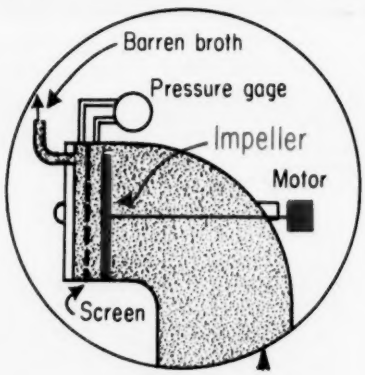
A new ion exchange process, which can absorb streptomycin from unfiltered whole nutrient broth, raises product yields from 72.9 to 84.7%. It also eliminates a costly filtration step. Yearly dollar savings realized by the process, now in commercial use at E. R. Squibb & Sons' New Brunswick, N. J., plant, run into the hundred thousands.

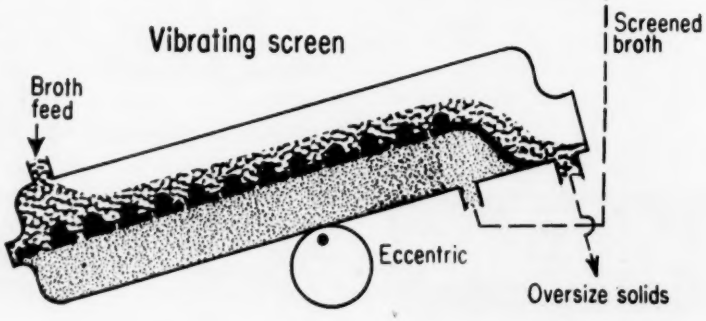
▶**No More Filtering** — Analogous to uranium winning by resin-in-pulp ion exchange (*Chem. Eng.*, 1957, p. 278), the new process requires much less cumbersome equipment, takes place in more or less conventional ion-exchange column. It may well be adaptable to uranium processing or to branches of metallurgy where it has heretofore been necessary to settle and/or filter before processing suspensions through ion-exchange columns.

The antibiotic streptomycin is produced by innoculating a solution or suspension of nutrients with a selected strain of streptomyces. During a four- or five-day growth period, tank contents assume the consistency of a thick soup. Streptomycin recovery normally consists, first, of filtering broth on

Turbine Impeller Keeps Column Open for Thick Pulp

Vibrating screen removes plus 100 mesh solids before broth enters column. Outlet screen keeps resin in column, passes pulp as impeller keeps screen open and maintains column flow.





precoat filters, then of absorbing the product from clear neutral filtrate on a carboxylic type ion-exchange resin.

But when Squibb microbiologists were able to increase the amount of crude streptomycin in the fermentation broth over 50 fold, changes in the nature of the broth dropped filtration rate to an unimprovable 10% of what it had been.

▶**Uses Existing Columns**—Engineers headed by Gerald Kleiman at Squibb Institute for Medical Research, seeking a way to go directly to the ion exchange step, ran head on into the problem of column and screen plugging. Process they ultimately developed solves, not only this major problem, but: It takes place in pre-existing ion exchange columns. It provides for simple maintenance and cleaning procedures. It can be carried out in the sanitary fashion required in the pharmaceutical industry.

▶**Agitator Opens Way**—Screen plugging was dealt with by selection of electroplated screens with tapered holes, and by optimum design and placement of an agitator to create high turbulence near screen.

With the narrowest cross-section of the screen's tapered holes facing the agitator, any particle smaller than this narrow cross-section goes through unimpeded. Any large particle stuck in the screen surface is removed by the scouring action of the impeller.

Agitation is supplied by a six-bladed turbine with a diameter about equal to that of the screen and set ½ to 1 in. from its surface. In columns of 48-in. diameter, tip speeds of 600 ft./min. yield sufficient scouring action to keep screens clean.

A secondary function of the agitator: A small amount of its energy dissipated into the bulk of the column helps provide the motion necessary to cause the broth slurry to flow freely through the resin bed.

▶**Bed Stays Porous**—For the rest, avoiding bed clogging proved to be easy by operating upflow, which maintains resin-bed particles in suspension, and of providing for proper size relationships between broth particles, resin particles and screen-holes.

Previous experience with ion-exchange processes had shown that, if a bed of particles is held in fixed position relative to a flow of slurry, the resin bed acts as a filter and clogs rapidly. On the other hand, even relatively slight motions of the resin particles in the bed (which Squibb's screen-scouring agitator provides) will permit the passage of a slurry if the size of the slurry particles is below that of the resin particles.

▶**Screen Removes Oversize**—A consideration of the elements of the whole-broth system showed that only a small fraction of the broth solids are larger than 100 mesh. These are screened out of the broth ahead of column. Most of the ion-exchange resin beads are somewhat larger than 50 mesh; small particles are excluded. So, it is possible to support and retain the ion-exchange resin on a screen of intermediate mesh size—actually, 60 mesh—which in itself offers no obstruction to the passage of the screened broth slurry.

Ion-exchange resin used in the process can be effectively screened to greater than 50 mesh by hydraulic classification in the column with water flow rates of 8 gpm./sq. ft. Resin attrition losses have been small.

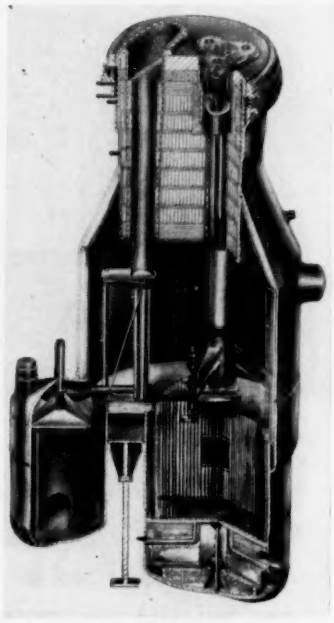
Only ½ of 1% total broth solids must be removed during prescreening. The effect on ultimate streptomycin yield is negligible. By way of contrast, for satisfactory operation of a continuous ion-exchange contactor recently developed for direct processing of uranium slurries, one half of all solids must be removed in advance.

Squibb's broth screening device is a self-cleaning vibratory screen, 100 square mesh. It consists of a simple sandwich containing an inclined screen with a top and bottom cover; it vibrates up to 2,000 cycles/min.

Materials which contain a large number of coarse particles screen and discharge their solids readily. The lack of such particles in Squibb's broth made it necessary to tack climber bars, approximately ⅛ in. dia., every inch or two the length of the screen in order to get maximum screening rates.

▶**Simple Modification**—For easy maintenance of the ion-exchange column: The retaining screen has been placed vertically at the end of a short elbow on the top of the column. The agitator has been positioned on the end of the shaft entering the side of the column opposite the screen.

Existing ion exchange columns were flanged at the top for easy addition of the elbow to house the screen agitator. A door was designed for easy opening and access to the screen whenever necessary.



Huge Fabrication Job Poses Design Problems

Uncommon shape and jumbo size of sodium-cooled reactor vessel above proved a continued source of joy for problem-happy engineers at Combustion Engineering, designer and fabricator of the vessel.

Developed from basic designs specified by Atomic Power Development Associates, Detroit, vessel will be installed at Enrico Fermi Atomic Power Plant, Columbia Park, Ohio, the U. S.'s first full-scale fast-breeder nuclear power plant.

The reactor measures 36 ft. high and 14½ ft. in dia. at the widest section (upper reactor vessel), is said to be the most complex stainless steel pressure vessel of its size ever built. It's designed for operating conditions of 50 psig. at 1,000 F. at upper vessel outlet and 110 psig. at 650 F. at lower vessel inlet.

Besides upper and lower reactor vessels, the unit has a transfer rotor container (appended at lower left) to provide for transfer and removal of fuel and blanket subassemblies, fuel-handling mechanism to transfer fuel, hold-down column (right-hand column in upper vessel) supporting control and safety rods, and 11-ft.-dia. rotating plug (top) used in refueling.

► **Chief Problems** — Main problems in fabrication were complicated by severe thermal and nuclear radiation and eccentric relation of the components.

Here's a sample of the problems engineers faced:

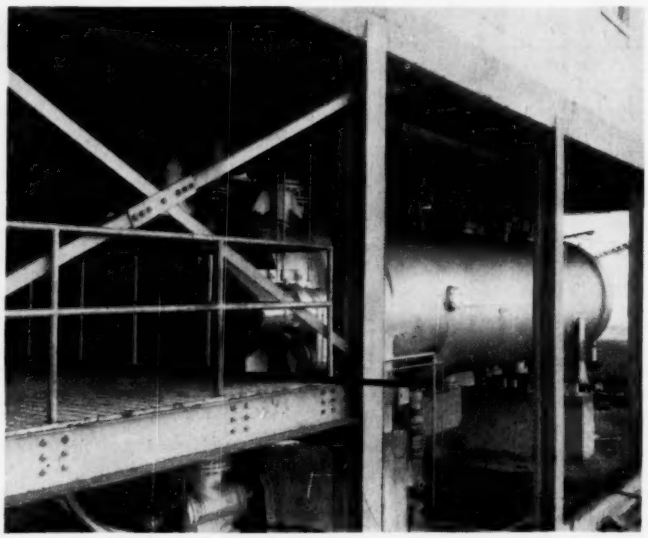
• Stainless steel is relatively difficult to control during welding. CE's practice, for welding major closures, was to have four welders working at the same time, positioned to maintain alignment of machined surfaces.

Critical need for accuracy led CE to check alignment and assembly constantly using optical methods.

• Liquid sodium flows upward through fuel and breeder blanket, tends to lift fuel from its support. CE uses hold-down column and plate to press down and prevent this.

Moreover, some of the low-pressure sodium is directed between annuli of the upper and lower vessel cylindrical shielding plates and between shielding plates separating the vessels. This posed a lot of problems in orificing sodium flow from lower vessel's low-pressure inlet.

• Rotating plug (used when refueling) is supported by a double row of ball bearings. Bearings and races are designed so that at refueling temperature, center lines of the balls will be nearly parallel to reactor center line. At other temperatures bearing center lines are not coaxial, so races had to be designed to accommodate a mismatch while still keeping four-point loading on the balls.



Continuous Digester Gets Better Pulp Faster

View from feed end of Sprout-Waldron continuous digester at new pulp mill of Sonoco Products Co., Hartsville, S. C., shows 8-ft.-dia., 40-ft.-long digester shell and variable-speed setup (left end of shell) which drives two pairs of screw conveyors. Recently developed digester (*Chem. Eng.*, Jan. 27, 1958, p. 86) boasts short cooking time and improved yield. Essentially two digesters in one shell, unit is designed to operate at 170 psig. with a retention time of about 11 min.

News Briefs

Polypropylene: Montecatini now plans to triple capacity of its polypropylene plant at Ferrara, Italy, within the next year. Plant has been on stream since last September.

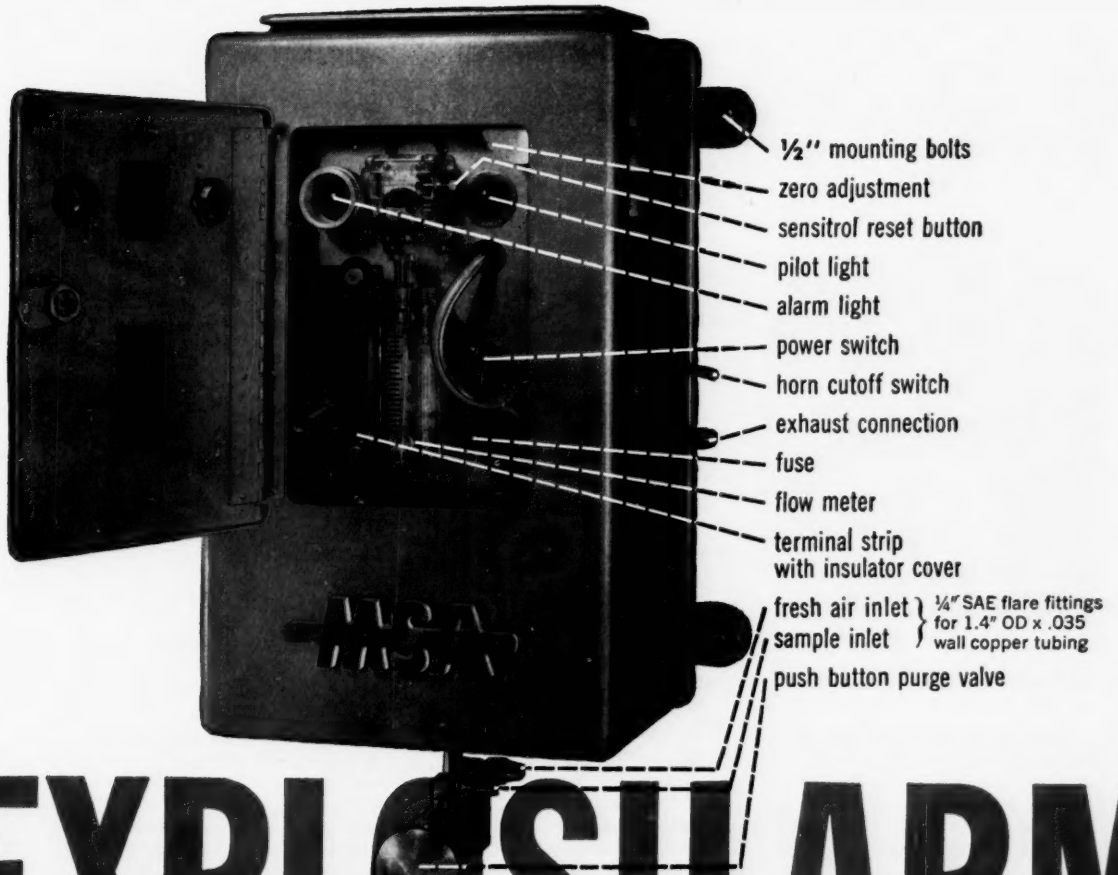
Miticide: Stauffer Chemical Co. has completed a new plant at Henderson, Nev., for making Trithion, an organic phosphate insecticide-miticide. Trithion, says Stauffer, is a nonsystemic compound effective against many insects.

Methanol: Escambia Chemical Corp. has now brought on stream its 16-million-gal./yr. methanol plant near Pensacola, Fla.

Ethylene: Mitsui Petrochemical Industries, at Iwakuni City near Hiroshima, and Sumitomo Chemical Co., at Niihama on the island of Shikoku, have both brought on stream major ethylene plants. Capacity of first plant is 22,000-tons/yr.; of second, 13,200 tons/yr. Both plants were designed by Stone & Webster Engineering.

High-energy fuel: Callery Chemical Co., this month will make the first shipment of high-energy boron fuel to the Navy from its new plant at Lawrence, Kan.

Alkyd, acetate resins: Reichhold Chemical Industries has started producing styrenated alkyds and polyvinyl acetate at its Mexico City site.



EXPLOSILARM

New M-S-A® Explosilarm is small, completely self-contained Combustible Gas Alarm—features low cost and low maintenance

Employed here, in the design of the Explosilarm, is over 30 years of MSA experience in the field of combustible gas analysis. This experience enables us to market a Combustible Gas Alarm offering minimum first cost, negligible installation cost, and very little maintenance. The result is greater economy and safer operations for the user.

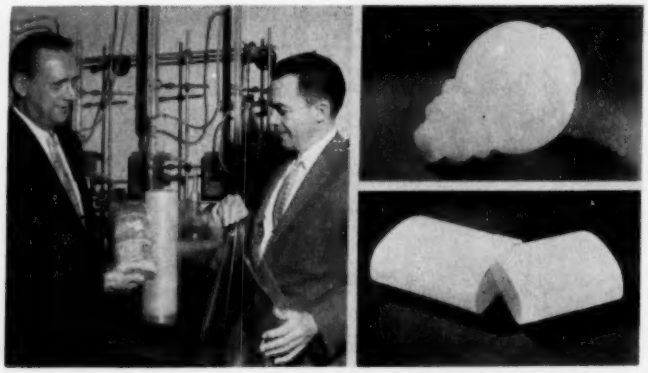
Accuracy and reliability of the Explosilarm are predetermined through the use of quality parts and fine craftsmanship. The platinum filaments in the balanced-bridge circuit are specially designed for long service life, interchangeability without matching pairs, and *extreme zero and calibration stability*. The locking panel prevents tampering with controls by unauthorized personnel, and assures proper operation without interruption.

The self-contained feature of the unit is important too. Motor and pump assembly, meter, relay, and all other components, are housed in a cabinet that measures only 8¾" wide by 14¼" high. This cabinet protrudes only 6¼" from the surface on which it is mounted.

An M-S-A Instrument Specialist will be happy to discuss your specific problems with you. Contact him soon. And write us for new bulletin on the operation of the Explosilarm.

INSTRUMENT DIVISION
Mine Safety Appliances Company
Pittsburgh 8, Pennsylvania

CHEMICAL PRODUCTS EDITED BY FRANCES ARNE



Stiffer Polyethylenes Find Commercial Niches

Spencer Chemical is producing a special medium density polyethylene resin developed in cooperation with Crown Zellerbach for use as a bread wrapper on high speed automatic overwrapping machines.

The plastic costs about 25 to 35% less than other transparent wrapping, has greater strength, longer service life, excellent moisture proofness, and heat-seal ability—Spencer Chemical Co., Kansas City, Mo. 60A

Thin-section rigidity and strength, high gloss, and chemical inertness has already prompted commercial use of new Bakelite high-density polyethylene in Wheaton Plastics Co.'s industrial soap dispenser (top) and perfume atomizer case.

Bakelite recently started up a 30,000-lb. plant in Institute, W. Va., using Ziegler-type catalysis to make the high density (low pressure) polyethylene—Bakelite Co., New York, N. Y. 60B

Isophthalic in Paint

First major paint company to include isophthalic in its paint.

A new house paint that has substantially increased color retention properties, and which holds its gloss longer than conventional-type oil paints, has been developed by W. P. Fuller & Co.

Improvements are credited to a new alkyd resin development contained in the basic formula. Isophthalic acid, instead of phthalic anhydride conventionally used, is reacted with a polyalcohol to form the new resin.

The new paint could represent a major market breakthrough for isophthalic acid, a brand new industrial chemical two years ago when Oronite Chemical Co. opened its $10-million, 50-million-lb./yr. plant at Richmond, Calif. (*Chem. Eng.*, Mar. 1956, p. 142). Alkyd paints have been considered the biggest potential market for isophthalic, with unsaturated polyesters and plasticizers providing significant, though smaller potential.

Fuller, largest paint manufacturer in the West, is the first major paint company to include isophthalic in a house paint formulation. At least one other company, Morwear Paint Co. of Oakland, Calif., has an isophthalic-containing paint on the market.—**W. P. Fuller & Co., San Francisco, Calif. 60C**

Dysprosium Metal

Another rare earth gets first pilot plant production.

Dysprosium metal, a rare earth formerly available only in tiny quantities, is now available in gram to pound lots. In lump and ingot form, it is of 98 to 99% purity.

The metal's neutron cross-section is 1,100 barns, which means that it has a great ability to absorb neutrons. This plus its relatively high melting point of 1,400 C. suggests use in nuclear-reactor control rods. Although several elements with high neutron cross-sections are presently available, the atomic energy industry has been looking for new ones with various combinations of temperature resistance, corrosion resistance, workability and weldability.

In electronics, dysprosium's paramagnetic properties qualify it as a component of ferrites, or garnets, a group of materials with applications in microwave equipment. Related to semiconductors, these materials are used in the new magnetic amplifiers known as masers. —**Research Chemicals, Inc., 170 West Providencia St., Burbank, Calif. 60D**

White Mineral Oil

Offers plastics manufacturers high viscosity, purity.

Newly developed white mineral oil will be of use to plastics manufacturers where a liquid of very high viscosity, exceptional purity and excellent heat stability is required. Called Ramol 500, it has a Saybolt viscosity range of 490/515.

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To get GREATER reactivity...USE–
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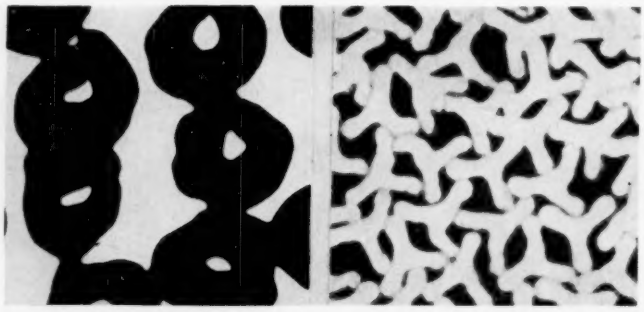


Symmetrical Cross-Sections Mark New Fibers

New acetate yarn, Eastman 50, is a doughnut shaped filament. Round, smooth surface, compared to irregular cross-section of conventional acetate yarn, imparts higher luster, greater bulk to fabrics.—Eastman Chemical Products, Inc., New York, N. Y. 62A

Type F acetate staple, with a Y cross section, was created because of its special adaptation to such uses as filling for innerspring matresses, furniture. It offers more bulk than conventional acetate staples, high resilience. — Celanese Corp. of America, New York, N. Y. 62B

The product is the latest addition to the company's complete line of U.S.P. and technical white mineral oils which are finding increasing acceptance in the plastics industry and in the manufacture of high-energy boron fuels.

White oils are being used as catalyst carriers and compressor oils in the plastic industry because their viscosities approach those of products they are replacing such as glycerine and polyalkylene glycol-type fluids and lubricants. White oils cost only about a fourth as much as these competitors. Their lubricating qualities are the same. They are available in a wide viscosity range of 40-500 at 100 F. and allow a user to select the grade best suited to his operation.

Some manufacturers of PVC resin have found the high degree of purity of white mineral oil very desirable, both in the production of the plastic and also in adding it to the plastic to give it a high sheen when used as a coating on wire.

Freedom from impurity is also the oils' attraction for manufacturers of exotic fuels. — **Continental Oil Co., Houston, Tex. 60E**

Protective Coating

Furan resin base compound stands acids, caustics, salt air.

Permaspray, a furan resin base protective coating, is now produced on a commercial scale after nearly a decade of testing and small-scale manufacture.

Unusual for a furan resin base coating, it will successfully adhere to metal. Tests indicate that it protects metal, concrete or wood against acids, caustics and salt air from three to ten times as long as other protective coatings.

A Permaspray coating on the HCl gas blower installed in the waste acid recovery unit of a Gulf Coast plant, subject to the constant corrosive attack of a 20% concentrate of HCl gas at 110 to 120 F., has stood up five years.

A blend of resin-forming liquids in solvents which facilitate its application, Permaspray does not deposit a film by solvent evaporation. It hardens by chemical action initiated by the addition of a liquid activator.

It withstands temperatures at 200 F. and, after drying, will not support combustion.—**Permaspray Mfg. Corp., P. O. Box 875, League City, Tex. 62C**

BRIEFS

Cellulose gums, three water soluble products called Methocel 60HG, 70HG and 90HG have been introduced. They feature improved organic solubility, higher thermo-gelation characteristics and special emulsion stabilization properties. —**Dow Chemical Co., Midland, Mich. 62D**

Liquid melamine-formaldehyde resin, called Melamine 3580, is said to be easier to handle than powdered melamines and to produce superior surface sheets in decorative laminates.—**Reichhold Chemicals, Inc., White Plains, N. Y. 62E**

Vinyl toluene-modified alkyd resins now being made in Holland constitute a further development and improvement of styrenized alkyd resins. In comparison with the latter they show greater stability, have improved spraying properties.—**Kunstharsfabrick Synthese, Katwijk, Holland. 62F**

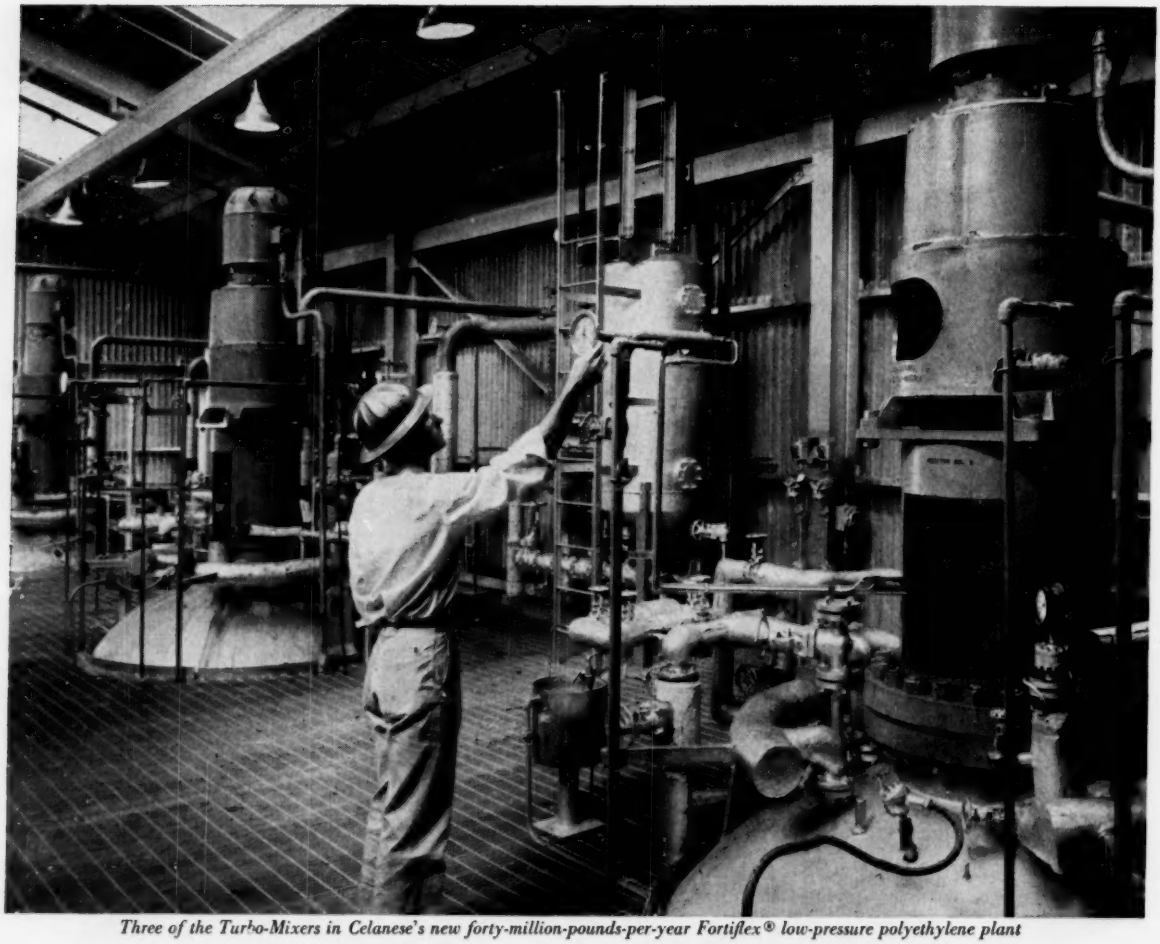
Dimethylamine salt of trichlorobenzoic acid, now available under the name Tryben 200, is said to be the first really effective weed killer for control of certain broad-leaved deep-rooted perennials and woody vines.—**Du Pont Co., Wilmington, Del. 62G**

For More Information . . .

about any item in this department circle its code number on the

Reader Service

postcard (p. 175)



Three of the Turbo-Mixers in Celanese's new forty-million-pounds-per-year Fortiflex® low-pressure polyethylene plant

for critical low-pressure polyethylene reactors,

CELANESE CHOOSES TURBO-MIXERS

The *formative reaction* is a critical step in the manufacture of Fortiflex®—now being made in the brand-new forty-million-pounds-per-year low-pressure polyethylene plant of the Plastics Division of the Celanese Corporation of America.

For this reaction, Celanese engineers had to have a mixer that would exactly maintain the correct mixing environment. For this reliability in design and performance, Celanese selected Turbo-Mixers. The above-pictured reactors are in the full scale plant (not the pilot plant). Turbo-Mixers serve in many operations in this and other polyethylene plants.

Turbo's 45 years of experience in design . . . Turbo's record of dependability . . . and Turbo's single-source responsibility make the difference. If you're in the process of selecting or specifying mixing equipment, call on Turbo. You'll find . . . *it pays to plan with General American.*

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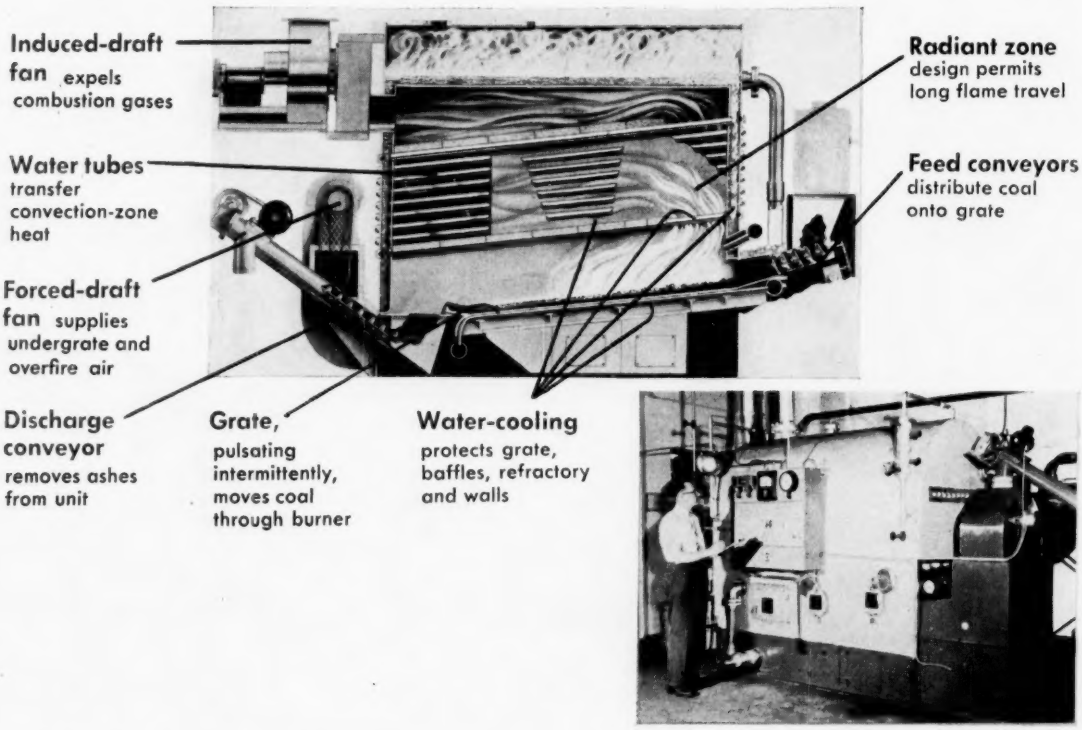


Automatic Coal-Fired . . .

Packaged Generator Yields Ready Steam

New unit combines all the advantages of a fully automatic packaged generator with the economy and efficiency of bituminous coal.

Steam—as much as you need when you need it; from bituminous coal—a low-cost fuel; via automatic operation — burning rate adjusts itself to load demands; in a packaged generator —ready to operate on arrival. These were some of the goals set by Bituminous Coal Research, Inc., when it started a packaged-generator development program several years ago.

Now for the first time, a commercial version of the BCR prototype is on the market, with operating installations already in service at Otterbein College, Westerville, Ohio, and Walter J. Engel, Inc., Florists, at Columbus, Ohio. Known as the Coal-Pak Automatic, it's available from The International Boiler Works Co. with capacities up to 10,000 lb./hr. of high- or low-pressure steam.

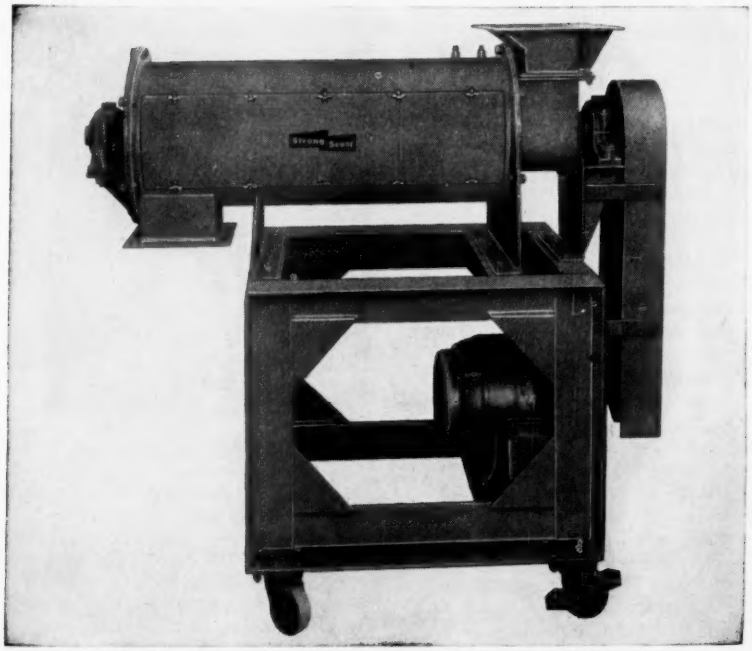
▶ **Check These Features** — The Coal-Pak Automatic crams a maximum of heating efficiency into a minimum of space. Completely assembled at International's factory, the package arrives ready for quick installation. Simple, foolproof controls constantly adjust the automatic coal feeder and air supply to meet the buyer's steam demands over a wide load range. A single toggle switch on the control panel changes normal operation to automatic hold-fire (maintenance of a small banked fire).

All four sides of the furnace, plus the top and bottom, are water-cooled for long life. The unit also features an automatic ash removal system that can be set to compensate for varying ash content of a wide range of coals. And, the unit keeps a clean stack regardless of the coal used —no dust collectors are required.

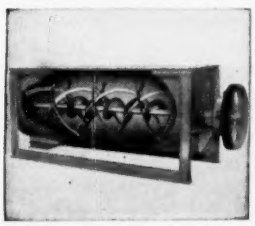
▶ **Operation at a Glance**—In operation, four 5-in. screw conveyors withdraw industrial steam-

NEW PRODUCT NEWS

NEW HIGH SPEED MIXER FOR QUALITY FINISHING

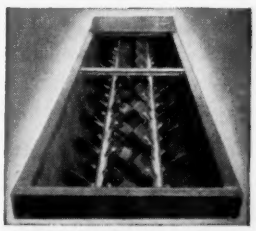


The Turbulizer produces a homogeneous mix, increases production while reducing mixing time and costs.



TRIPLE ACTION MIXER—Complete uniform blending in 2 to 7 minutes.

STRONG-SCOTT TRIPLE ACTION MIXER exposes each particle in the mixture to over 10,000 separate mixing actions per minute as it blends and folds. This produces a uniformly mixed product with 99.9% thorough distribution of minor additives.



TWIN ROTOR MIXERS—Accurate blending of liquids and dry mix at any speed.

TWIN ROTOR MIXERS are designed primarily for high percentages of liquid application to light weight ingredients, where product identity is to be maintained. A double shaft assembly with overlapping, adjustable paddles gently combine the liquids with the dry mix.

STRONG-SCOTT TURBULIZER

Provides Fast, Thorough Dispersion, Disintegration and Blending of Dry Materials, or Pastes Involving Liquids and Solids.

The TURBULIZER is a high speed, continuous mixer that will disintegrate and disperse fat pellets, chemical ingredients which have a tendency to ball or agglomerate, and other ingredients which can be broken by the paddles and thoroughly dispersed in the mixture. Product uniformity is accurately maintained as a result of high speed centrifugal forces created by the paddles.

It is also highly applicable where a fluffing action is desired on powdered material. Minor percentages of liquid may easily be added to dry mix with high efficiency and dispersion results.

The TURBULIZER is self cleaning and is built with sanitary seals at each end of the shaft. The interior is precision machined. Overlapping, adjustable paddles turn within a close tolerance to the chamber wall, providing a selective rate of material flow.

The TURBULIZER may be furnished in carbon or stainless steel and may be jacketed for hot water, steam or a refrigerant. Capacities will vary depending on the bulk density of the material and the degree of agglomerates encountered. Consult Strong-Scott for full details.

SEE OUR COMPLETE LINE OF EQUIPMENT IN THE 1958 CEC PAGES 1709-1712

size coal from the feed hopper, and intermittently distribute it in a thin, even layer on the pulsating grate; these conveyors also serve as effective barriers against burn-back to the bin. The grate moves the burning coal through the firing zone, then discharges the ashes into a pit. Another screw conveyor, with one end in the pit, periodically removes ashes from the unit.

An induced-draft centrifugal fan draws combustion products through the various boiler passes and out of the furnace. It also maintains the negative furnace pressure essential to clean, safe operation. A second fan, part of the forced-draft system, supplies both undergrate and overfire air. Integrated control circuits regulate all equipment in accordance with steam demands.

▶**More About Boiler, Stoker**— Special features inherent in the boiler and stoker merit additional mention.

All tubes in the boiler are slightly inclined to assure natural circulation with consequent rapid steam delivery. Baffles and staggering techniques arrange some of the tubes into a two-pass radiant-heating zone and a convection zone.

Other tubes find use in cooling the grate, walls, baffles and top of the furnace. Thus, a minimum of refractory is required, greatly reducing the necessity for boiler maintenance. This functional arrangement of tubes and baffles, while compact, still provides the high furnace volume and long flame path needed to burn high-volatile bituminous coal.

The stoker's water-cooled pulsating grate is also of special BCR design. Consisting of cast-iron surface bars set into a grid of water tubes, the grate has a horizontal reciprocating motion that gives unidirectional fuel-bed travel. The drive motor, during that portion of the cycle in which it's operating, pulsates the stoker through a ½-in. amplitude at a rate of several hundred vibrations per minute. This gives a positive bed travel of about ½ in./sec. during stoking. Little or no vibration is transmitted to the boiler.

▶**Controls Merit Mention Too**— The absence of electronic circuits utilizing vacuum tubes, rectifiers or condensers makes the Coal-Pak Automatic control system simple and rugged. All components except two special cam-actuated timers are "off-the-shelf."

Signals from a pressure-sensing element in the boiler translate changes in load demand to a change in the position of a master cam. The cam, through various motors, timers and interlocks, relocates the various equipment settings to adjust firing rate.

For example, when load increases, the feed screws deliver more coal onto the grate, which pulsates for a longer time interval per cycle. Also, the dampers open to deliver more air, and the ash conveyor operates more frequently.

Safety devices include a low-water cutoff, a no-draft limit switch and a high-pressure limit switch.

▶**High or Low-Pressure Models** — Coal-Pak Automatic units come in two series—one for high pressures, the other for low. Type PSH generates 125, 150 or 200-psig. steam; Type PSL delivers steam at 15 psig. Six sizes are available in each series, and range from 71.6 to 300 hp., a maximum of 10,000 lb./hr. — **The International Boiler Works Co., East Stroudsburg, Pa. 66A**

Recording Photometer

Continuously measures and records stream turbidity.

A new industrial recording photometer, developed and now manufactured in Switzerland, continuously determines and records accurate absorption or turbidity values for control of industrial processes.

Automatic, built-in compensation devices constantly adjust the Sigrist-Photometer to compensate for undesirable variables. Thus, fluctuation of light source, variable sensitivity of photocells, and amplification rate of generated photocurrent have no effect on the instrument's accuracy.

The unit has already proved its merit in some 200 installations. Typical applications include the continuous control of filtration, clarification, extraction and decolorization processes.—**Renupp Co., Greenfield Ave., Los Angeles 34, Calif. 68A**

Process Optimizer

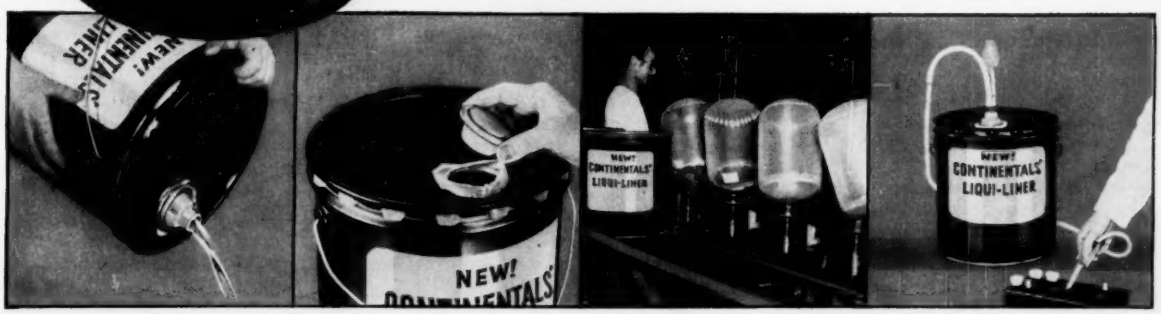
Unlike the plant operator, it doesn't eat.

After several years of development, Westinghouse is ready to apply their Automex optimizing controller on an experimental basis to selected processes. Automex can optimize the yield of a process, minimize its cost, or maximize the throughput.

Conventional controllers function by keeping a process variable at a given set point; Automex, however, coordinates the set points of many controllers. Principle requirement for proper functioning is accurate measurement of the variable to be optimized. Instruments such as spectrophotometers, polarographs and spectrographs are undergoing intensive conditioning for this on-stream analysis job.

The best asset of Automex is ability to optimize while both controlled and uncontrolled process characteristics are varying with time. Although standard units are not yet available for widespread distribution, Westinghouse predicts a near-future unit selling between $10,000 and $20,000.—**Westinghouse Electric Corp., Box 2278, Pittsburgh, Pa. 68B**

SAVES TIME... SAVES MONEY IN SHIPPING AND DISPENSING CORROSIVE AND HARD-TO-HOLD LIQUIDS



Splash Free Pouring! Polyethylene Flex-spout is shipped loose, attached after filling, provides splash free pouring.

Recessed Spout, Tamper Proof Seal! Spout recesses, is covered with tamper-proof seal during shipping and storage.

Tested Leakproof! Polyethylene bags are air-tested for leakage before and after insertion in pail.

Safe, Fast Dispensing! For corrosive liquids, dispensing pump is available, assuring safe, no-waste dispensing.

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A PACKAGE WITHIN A PACKAGE! Liqui-Liner is a five-gallon container fitted with a leakproof polyethylene bag, assembled by Continental, and shipped to the user with cover crimped on ready for filling through spout opening.

PRECISION-MADE FOR POSITIVE PROTECTION. Liqui-Liner assures positive protection for products which are corrosive or have a low iron tolerance. Heavy gauge steel container provides maximum protection against shipping damage. Custom-tailored bag fits container exactly, protects against product contamination and leakage.

SUBSTANTIAL SAVINGS! Liqui-Liner reduces shipping and handling costs! No outer carton is needed. Larger capacity means fewer containers can be used. Wide spout hole makes filling fast and easy. Recessed spout permits stacking; wire bail handle assures easy carrying.

PACKAGING CONVENIENCE AND ECONOMY! Dispensing is easier with Liqui-Liner—from dispensing pump or splash free spout. Large, smooth surface accommodates attractive lithography for permanent advertising. The empty steel container has utility use after original content has been used.

IF YOUR PRODUCTS require low-cost Liqui-Liner protection, call your nearest Continental representative for complete details.

CONTINENTAL CAN COMPANY

Eastern Division: 100 E. 42nd St., New York 17
Central Division: 135 So. La Salle St., Chicago 3
Pacific Division: Russ Building, San Francisco 4
Canadian Division: 5595 Pare St., Montreal, Que.

Front-End Loader

Combines several new design features.

According to the manufacturer, the H-25 Payloader is the first rubber-tired, front-end loader with a rated carrying capacity of 2,500 lb. Not an expansion of the company's standard HA Payloader line, the H-25 features all new design.

New power-shift transmission and torque converter are matched for speed of movement and ease of operation. Power steering is standard; turning radius is only 6 ft. to the outside rear hub. A complete air and oil filter system protects the engine from dust.

The H-25 is available with a choice of gasoline, diesel or LPG power. — **The Frank G. Hough Co., 754 Seventh Ave., Libertyville, Ill.** 70A

Equipment Cost Indexes

	Dec. 1957	March 1958
Industry		
Avg. of all	229.2	231.2
Process Industries		
Cement mfg	220.7	222.9
Chemical	230.4	232.4
Clay products	214.4	216.6
Glass mfg	217.6	219.4
Paint mfg	221.6	223.8
Paper mfg	222.0	223.9
Petroleum ind	226.3	228.6
Rubber ind	229.1	231.4
Process ind. avg	227.0	228.8
Related industries		
Elec. power equip	232.9	234.2
Mining, milling	231.8	233.8
Refrigerating	258.9	261.5
Steam power	216.9	219.5

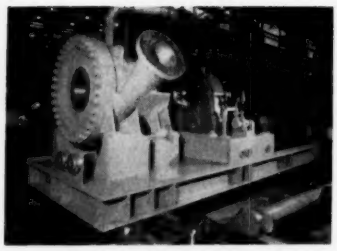
Compiled quarterly by Marshall and Stevens, Inc. of Ill., Chicago, for 47 different industries. See Chem. Eng., Nov. 1947, pp. 124–6 for method of obtaining index numbers; Feb. 24, 1958, pp. 143–4 for annual averages since 1913.

For More Information . . .

about any item in this department, circle its code number on the

Reader Service

postcard (p. 175)



Compressor

Boasts compact design and few wearing parts.

Operating at working pressures up to 500 psia., a new single-stage centrifugal compressor may find wide application for boosting process-line gas pressure. By contrast, conventional single-stage compressors have a maximum working pressure of about 50 psia.

The high-pressure, smooth-running unit has a compact, barrel-type casing assembly consisting of a casing cylinder, bolted casing head and the bearing pedestal.

Other design features include a welded impeller, sleeve-type load bearing with removable liners, and a Kingsbury-pivoted shoe thrust bearing. Rotating assembly is statically and dynamically balanced. Ratings are available as required. — **Allis-Chalmers Mfg. Co., Milwaukee 1, Wis.** 70B

BRIEFS

Oxygen analyzer automatically and continuously detects as little as one part per billion of dissolved oxygen in high-purity water. Signal output is 0-5 millivolts.—**Beckman/Process Instruments Div., Fullerton, Calif.** 70C

A new venturi, the Twin-Throat, produces higher differential pressure or lower head loss in a much shorter laying length. It comes in a full range of sizes. — **Infilco, Inc., P. O. Box 5033, Tucson, Ariz.** 70D

Pneumatic transmitter line now includes new types of pressure transmitters of indicating and non-indicating types, a bellows-actuated indicating pressure transmitter, and an indicating temperature transmitter.—**Manning, Maxwell & Moore, Stratford, Conn.** 70E

Thermal balance, consisting of a highly precise spring balance enclosed in a vacuum chamber, automatically records weight changes as a function of temperature or time. — **American Instrument Co., Inc., 8030 Georgia Ave., Silver Spring, Md.** 70F

Metering pump, constructed from stainless steel or nickel alloy for sanitary operation, provides accurate discharge rates from 0-25 gpm. Unit disassembles easily for cleaning.—**The Waukesha Foundry Co., Waukesha, Wis.** 70G

Rotary blower line, designed to deliver 10-1,100 cfm. at pressures from 5-25 psia., features wide-face herringbone gears and a timing hub that permits field adjustment of impeller clearance and timing.—**Sutorbilt Corp., 2966 East Victoria St., Compton, Calif.** 70H

Rupture disks made of impervious graphite now come with ratings up to 300 psi., for any temperature to 650 F. Diameters range from 2 to 24 in.—**Falls Industries, Inc., Aurora Rd., Solon, Ohio.** 70I

Check weigher can electronically spot a 1% weight variation of packages moving at rates of 400/min.—**Food Machinery and Chemical Corp., FMC Div., 4900 Summerdale Ave., Philadelphia 24, Pa.** 70J

Lift truck can raise a 4,000-lb. load to a height of 30 ft. Overall collapsed height is 220 in. — **Yale Materials Handling Div., The Yale & Towne Mfg. Co., 11000 Roosevelt Blvd., Philadelphia 15, Pa.** 70K

Gear pump features hard-rubber casing and gears, Kel-F bearings and rubber-covered shaft. Complete with ½-hp. motor, the pump delivers a maximum of 12 gpm. Maximum head is 52 psi.—**American Hard Rubber Co., Div. of Amerace Corp., Ace Rd., Butler, N. J.** 70L

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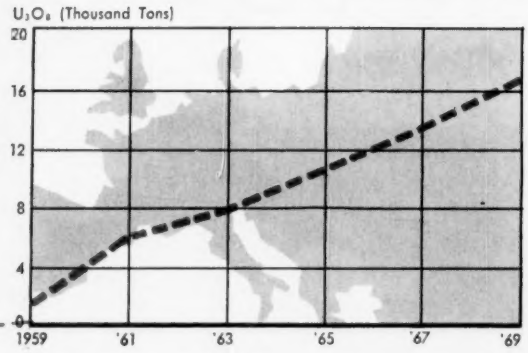
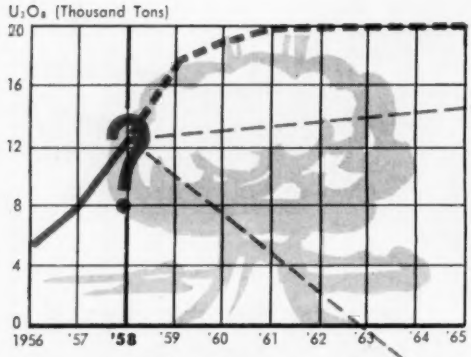
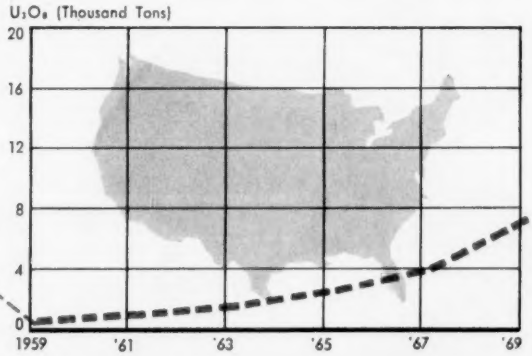
Uranium processors wonder: Where do we go from here?



Foreign power markets: Clear-cut, close at hand, but contingent upon AEC security.



Government markets: The urgency of military needs will be easing.



U. S. power markets: Ten years away, nebulous, they are not much incentive now.

Uranium Industry Needs a New Incentive

C. S. Cronan, Associate Editor

Viewed from some angles, production of uranium has been a dream business—one customer committed to take a definite amount of product at a guaranteed price.

But like all dreamers of good dreams, uranium producers have wakened to find the dream business suddenly complicated by rapidly changing factors:

• Rapidly swelling supply now satisfies present demand (mostly for weapons) from the one and only customer, the AEC.

• Domestic demand for uranium to fuel power reactors will eventually climb rapidly, necessitating greatly expanded reserves. But this surge is a good ten years away.

• Short-term incentive now becomes important to encourage investors to back exploration needed to build reserves of ore to the level where they'll be adequate for the long-term demand.

• Foreign needs are substantial enough and close enough to provide the needed incentive for continued growth. But hope of winning overseas markets may fail to hurdle security barriers.

▶ **Output Now Doubling**—Right now, output of uranium from U. S. mines and mills is in the midst of an upward surge that will double consumption of ore in the two-year period between 1957 and 1959. Beyond that point, mining and milling may level out some 15% higher at around 8-million tons/yr. (about 20,000 tons of U_3O_8.

The push behind this big upsurge has been AEC's willingness to purchase new output on long-term contract as fast as it was developed. So effective has been this stimulus that last October, in order to prevent gross surpluses, the AEC had to call a halt to further expansion of its uranium purchases.

The 15% rise above the 1959 level is AEC's recent evaluation of what it will need to purchase

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in order to prevent heavy losses to private capital already committed to partially developed mining properties.

▶**Need More Exploration** — Up to this point, everything seems to be working out. Present estimates of ore reserves stand at 78 million tons, sufficient for about 9 yr. production at present committed levels. But, there is need to continue exploration and development of reserves just to assure supplies to the projected government market, to say nothing of the expected boom in commercial power needs.

However, AEC's report issued March 31st on "Domestic Mining and Milling Problems Resulting from Limitation on Additional Milling Capacity" states that rate of exploration and development can be expected to decline sharply for a time if there is no longer an expanding uranium market.

The report states further that private industry's maintenance of adequate ore reserves for the industrial market in the post-1966 period will be based largely on its appraisal of that market.

At present, industry in general has confidence that there will be a substantial future industrial market. But it has little firm data upon which to estimate the size and timing of that market. As long as this uncertainty exists, exploration and development for the future market will proceed cautiously and on a limited scale.

▶**Hope From Abroad**—This uncertainty could be dispelled by fast-moving developments in foreign nuclear-power programs.

As we all know, Great Britain is moving rapidly toward widespread utilization of nuclear power. Proceeding under full government financing, Great Britain has or is constructing plants totaling about 1 million ekw. By 1965, installed capacity will reach 6 million ekw.

In Western Europe, the Euratom countries undoubtedly represent the world's largest potential market for nuclear power plants. If these countries follow through on recommendations contained in the report, "A Target for Euratom," by Armand, Etzel and Giordani (the three wise men), they will install 15 million ekw. of nuclear power capacity by 1967 representing total investment of $5.25 billion exclusive of fuel inventory.

Lumped together, these two projected developments supplemented by a few smaller ones in other countries* could be the commercial market needed to stimulate uranium producers during the interim period of the next 8-10 yr.

With a dominant position in supplies of uranium, enriched uranium and heavy water, the U. S. could compete very well on the world market for this business as it develops.

▶**Hurdle Security Blocks** — Before this happy state develops, however, certain conditions must be fulfilled. At Denver, Feb. 8, 1958, AEC's Jesse Johnson acknowledged before the National Western Mining Conference that in view of uranium supply now exceeding AEC's demand "The question of a commercial market for uranium, or the approval of private sales, will be considered by the Commission . . . It is necessary, however, to establish the detailed conditions for a domestic buyer or foreign buyer to qualify for a license. The principal problem relates to the controls and safeguards with respect to export sales."

Evidence of the problems we face in getting AEC licenses for commercial export of nuclear fuels was evidenced in mid-April by difficulties which arose with the Euratom nations. At that time, preliminary negotiations, leading to eventual installation of 15 million ekw. of nuclear power, were stalled over control problems.

As commercial power facilities come into being, they'll be producing byproduct plutonium, heart of atom bombs. Uncle Sam wants to keep it from straying into irresponsible hands. Unless this hurdle is cleared, there'll be little immediate commercial market for U. S. fuel.

▶**More Process Development**—If U. S. uranium producers gain access to foreign commercial outlets, it may also stimulate them to undertake further process development aimed at lower product cost.

To date, tremendous strides have been made in recovering uranium values from raw ore with various leaches followed by solvent extraction or ion exchange. Much credit goes to Jesse Johnson's AEC Div. of Raw Materials and its industrial and institutional contractors who carried out the research and development work on the processes now used by uranium mills.

Unfortunately, now that AEC has curtailed further expansion, it is also terminating these projects. Any further AEC work on raw materials will probably be mainly piecemeal jobs located in the Salt Lake Bureau of Mines laboratory.

But, if ore millers are to push for lower costs normally associated with successful ventures, they'll have to undertake some additional research and development on their own.

*Japan envisions a nuclear power capacity of one million ekw. by 1965.

Chemical Consumption

Consumption by Industries

	Jan. (Final)	Feb. (Est.)
Coal products	8.6	7.2
Explosives	9.3	8.4
Fertilizer	74.2	70.2
Glass	25.8	24.3
Iron & steel	12.4	10.6
Leather	4.0	3.9
Paint & varnish	28.9	25.0
Petroleum refining	30.9	26.5
Plastics	24.2	21.8
Pulp & paper	37.0	33.6
Rayon	25.6	21.8
Rubber	6.4	5.6
Textiles	9.8	8.5
Total	**297**	**267**

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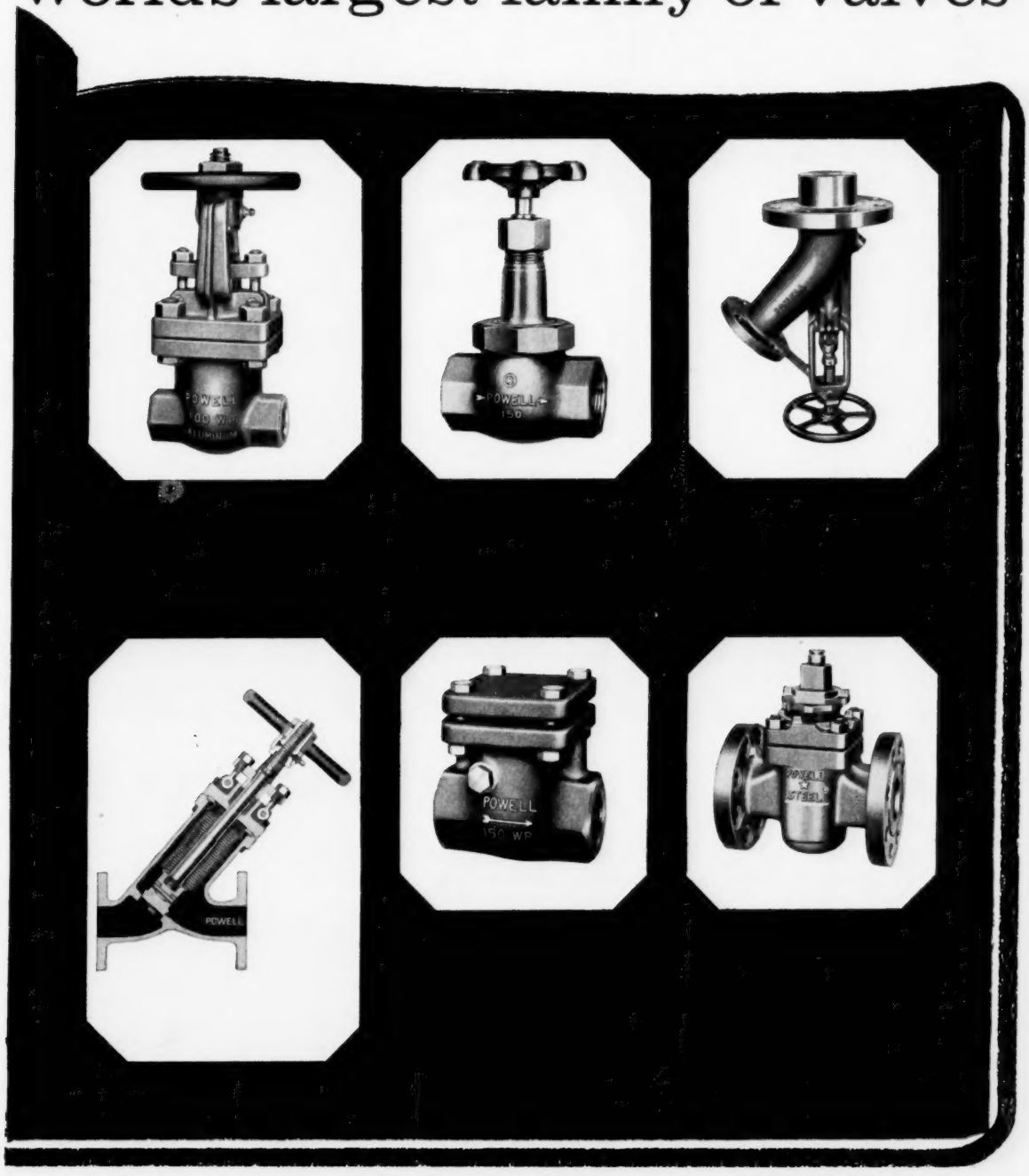

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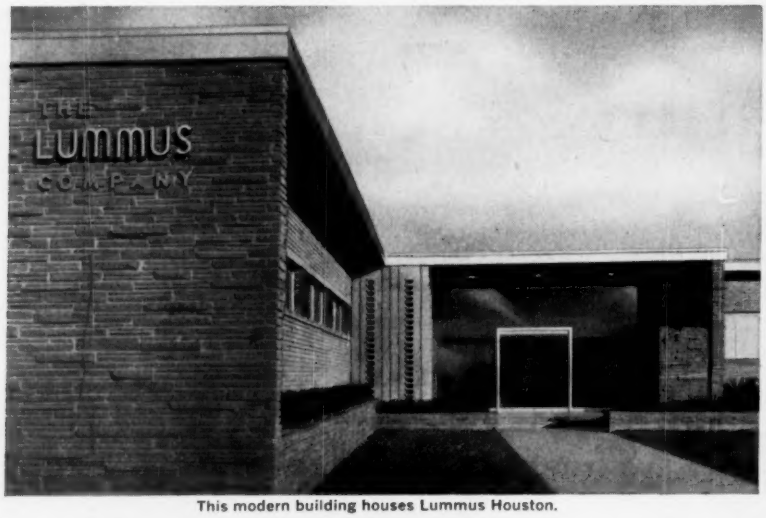
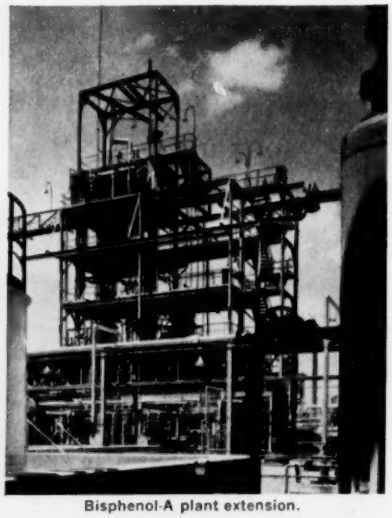


This modern building houses Lummus Houston.



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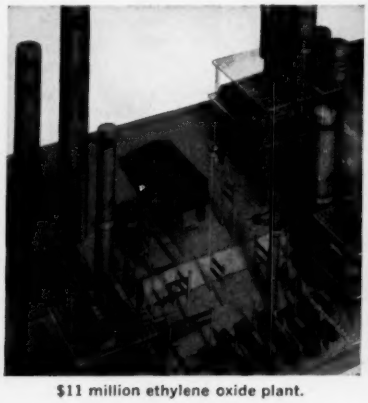
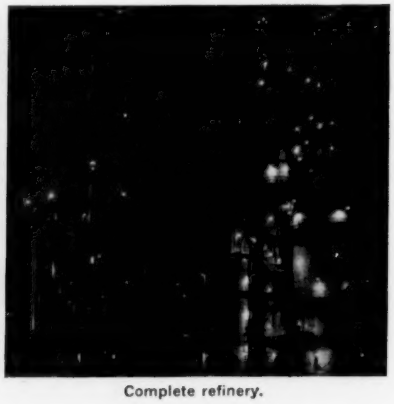


$11 million ethylene oxide plant.



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by d'Arazien

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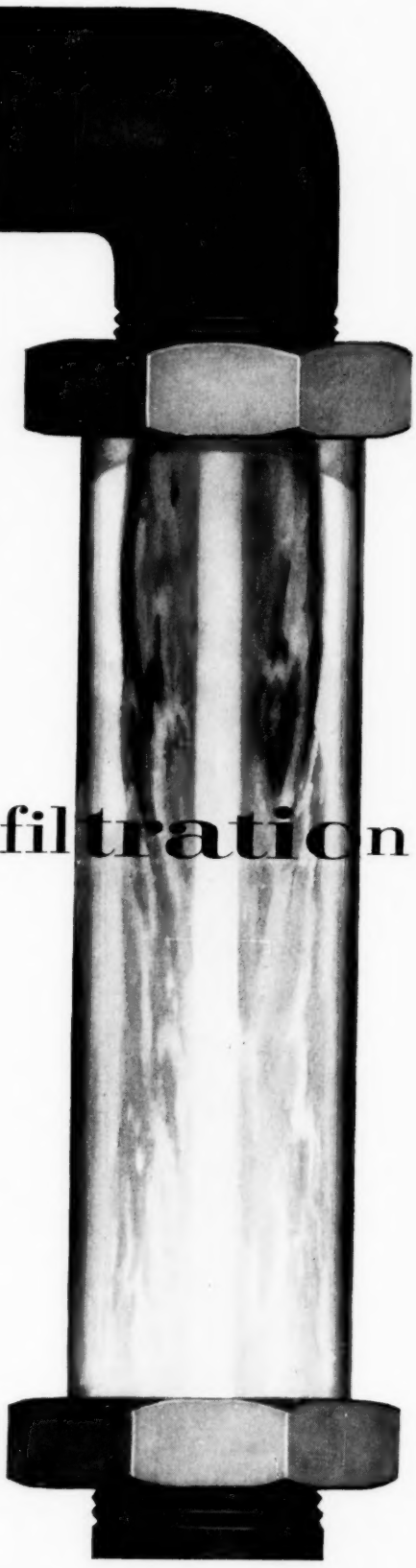

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HEAT TRANSFER AUTHORITY CONSULTANT TO NATIONAL CARBON COMPANY

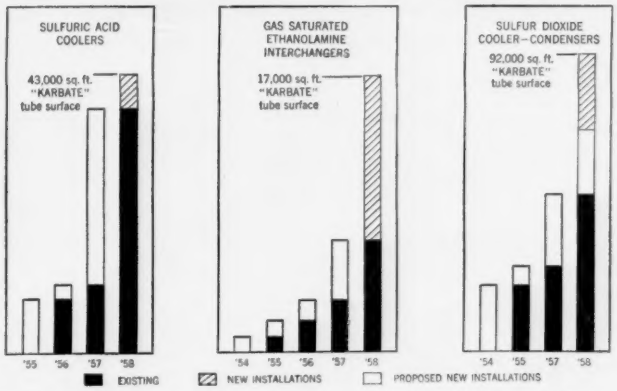
DR. DONALD Q. KERN

D. Q. Kern and Associates, specialists in thermal design of chemical process units, work with National Carbon Company in developing and applying "Karbate" impervious graphite heat transfer equipment.

Before establishing his own organization, which serves many U. S. and Canadian companies, Dr. Kern had a distinguished career in industry. Concurrently, from 1943 to 1953, he was professor of chemical engineering, The Graduate School, Polytechnic Institute of Brooklyn. Here he was in charge of advanced instruction in heat transfer and thermodynamics. He is also author of the text, PROCESS HEAT TRANSFER, now in its seventh printing.

"Karbate" Heat Exchangers prove economically superior in corrosive processes

Charts below show expanding use of "Karbate" impervious graphite in three typical corrosive services



"Karbate" impervious graphite resists all concentrations of sulfuric acid up to 60% at temperatures to boiling. This combined with resistance to thermal shock makes "Karbate" heat exchangers logical choices for heating and cooling sulfuric acid.

Long life and moderate costs frequently make "Karbate" heat exchangers the preferred choice over metal units in ethanolamine service. In addition, the improved corrosion resistance permits operation at far higher velocities thus making possible several fold reductions in required heat transfer area.

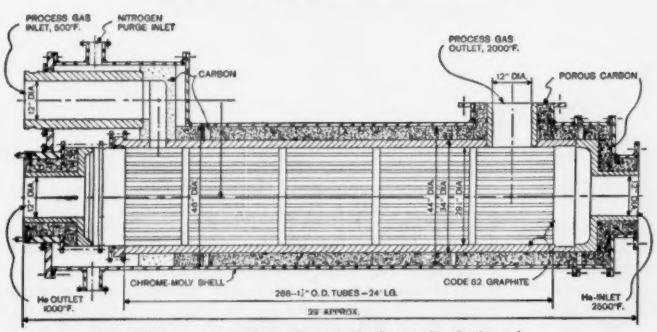
The large surface areas required for cooling – condensing of wet sulphur dioxide containing gases are provided conveniently and economically by "Karbate" shell and tube heat exchangers such as shown below. The corrosive gas is handled on the tube side permitting easy access for cleaning.

"National", "N" and Shield Device, "Karbate" and "Union Carbide" are registered trade-marks of Union Carbide Corporation.

UNION CARBIDE

NATIONAL TRADE-MARK

Graphite Heat Interchanger Designed for Use with Nuclear Reactors

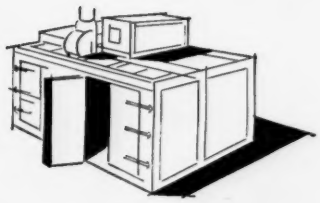


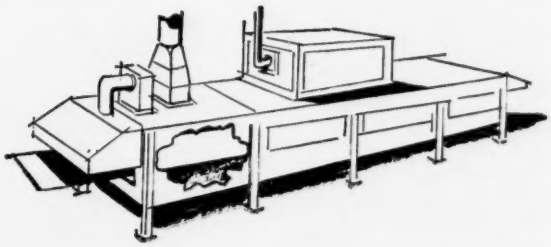
This gas phase interchanger is thermally designed to handle heat generated in a 5 megawatt reactor.

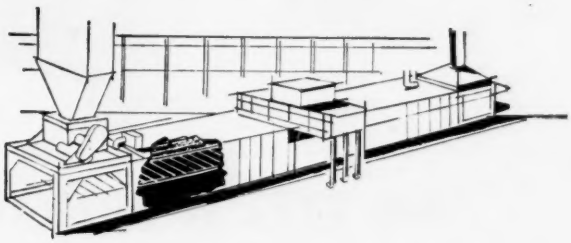
Interest increases in the use of nuclear generated heat for chemical processing applications. In such operations, a gas heat interchanger of the type shown would operate in a loop with the reactor. Hot helium gas from the reactor circulates through the tube side of the exchanger, while process gas to be heated passes through the shell side.

Because operating temperatures range from 2000° to 2500° F., "National" Code 82 graphite is well suited for such applications. This low permeability material used for constructing the shell and tube heat exchanger shown provides high heat transfer rates, freedom from corrosion and metallic contamination, and resistance to thermal shock.

Armco ALUMINIZED STEEL makes dryers last longer, BTU's work harder







Hot-dip aluminum coated Armco Steel offers high heat reflectivity, resistance to heat and corrosion at low cost

In batch or continuous dryers and other equipment exposed to heat and corrosion, Armco ALUMINIZED STEEL Type 1 gives you opportunities to cut costs. This two-in-one metal has a combination of advantages provided by no other material in its price class.

RESISTS HEAT

The coating on ALUMINIZED STEEL Type 1 is not affected by temperatures to about 900 F, and resists destructive scaling up to 1250 F. Its steel base provides structural strength at those temperatures, and resists both fire and mechanical damage much better than solid aluminum.

RESISTS CORROSION

Extensive use where it has been exposed to moisture, heat, and products of combustion shows that ALUMINIZED STEEL Type 1 has economical durability. It protects products from contamination.

REFLECTS HEAT

Up to 900 F, ALUMINIZED STEEL reflects about 80% of incident radiant heat. It helps keep heat where you want it, increases efficiency of drying operations.

Proved applications of ALUMINIZED STEEL Type 1 in the chemical industry include reactor covers, stack rain shields, insulating covers, radiant heat reflectors, stationary engine mufflers and drying ovens of all types.

A companion grade, Armco ALUMINIZED STEEL Type 2, recommended for service up to 900 F, has even greater corrosion resistance. Let Armco Engineers help you select the best type for your job.

For *your* equipment, specify Armco ALUMINIZED STEEL. You can be sure of durability, dependability and economy. For complete information, just fill out and mail the coupon. Armco Steel Corporation, 2228 Curtis Street, Middletown, Ohio.

ARMCO STEEL CORPORATION, 2228 Curtis St., Middletown, Ohio

Send me information on Armco ALUMINIZED STEEL Type 1.
We are considering it for_____

New steels are born at Armco

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TITLE _____

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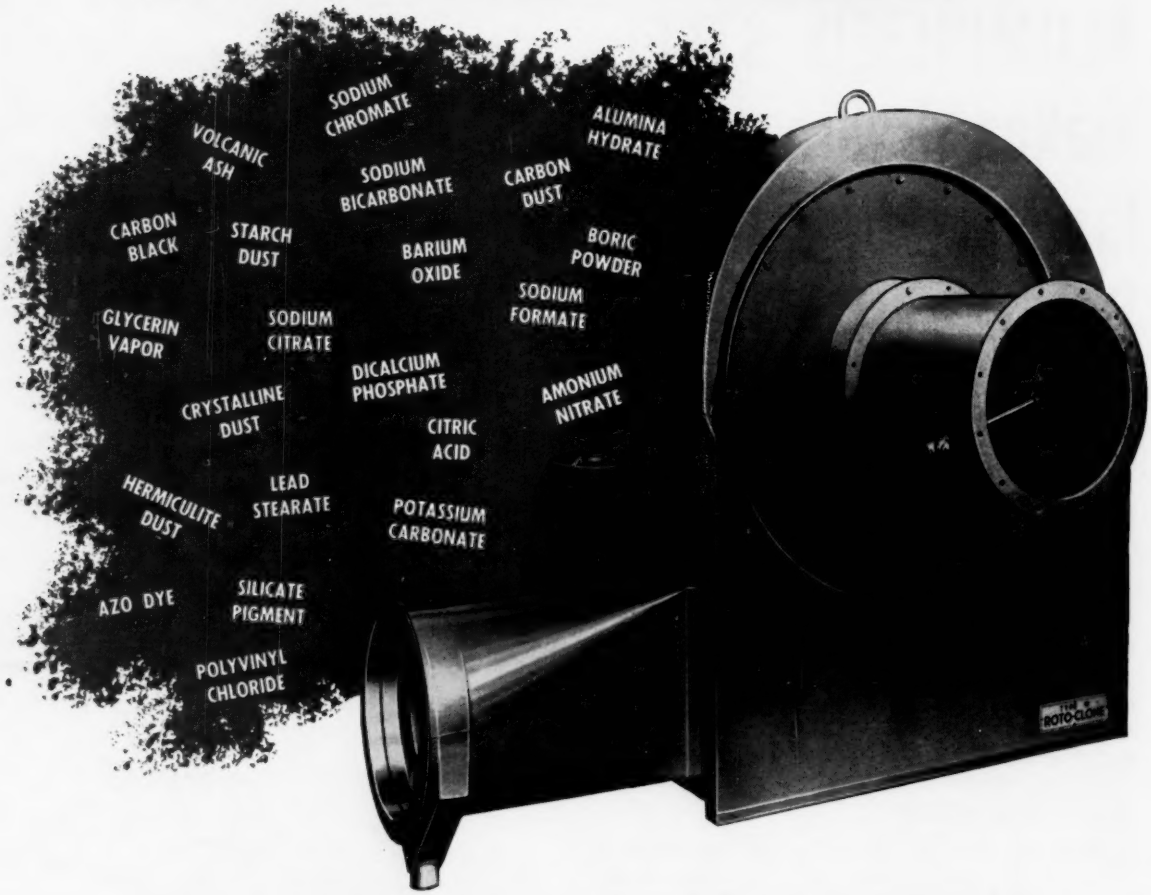
ARMCO STEEL

Armco Division • Sheffield Division • The National Supply Company • Armco Drainage & Metal Products, Inc. • The Armco International Corporation • Union Wire Rope Corporation • Southwest Steel Products

Do you have a DUST PROBLEM?



AAF TYPE W ROTO-CLONE DOES MANY JOBS FOR CHEMICAL PROCESSORS

If your operations require collection of fine dust particles in moderate concentrations, you've got a job for the AAF Type W ROTO-CLONE.

The ingenious addition of water sprays extends the effectiveness of this dynamic precipitator to collection of the finest, lightest dust particles. The compact Type W ROTO-CLONE provides everything you need, except duct connections, in one complete shop-assembled package.

The Type W requires little maintenance, uses a minimum of water and maintains efficiency regardless of variation in air volume. It can be made of special metals or protected with most coatings at modest cost. For complete information, call your local American Air Filter representative or write direct for Bulletin 272B.

AAF Dust Control Equipment

Illinois Heating Specialties

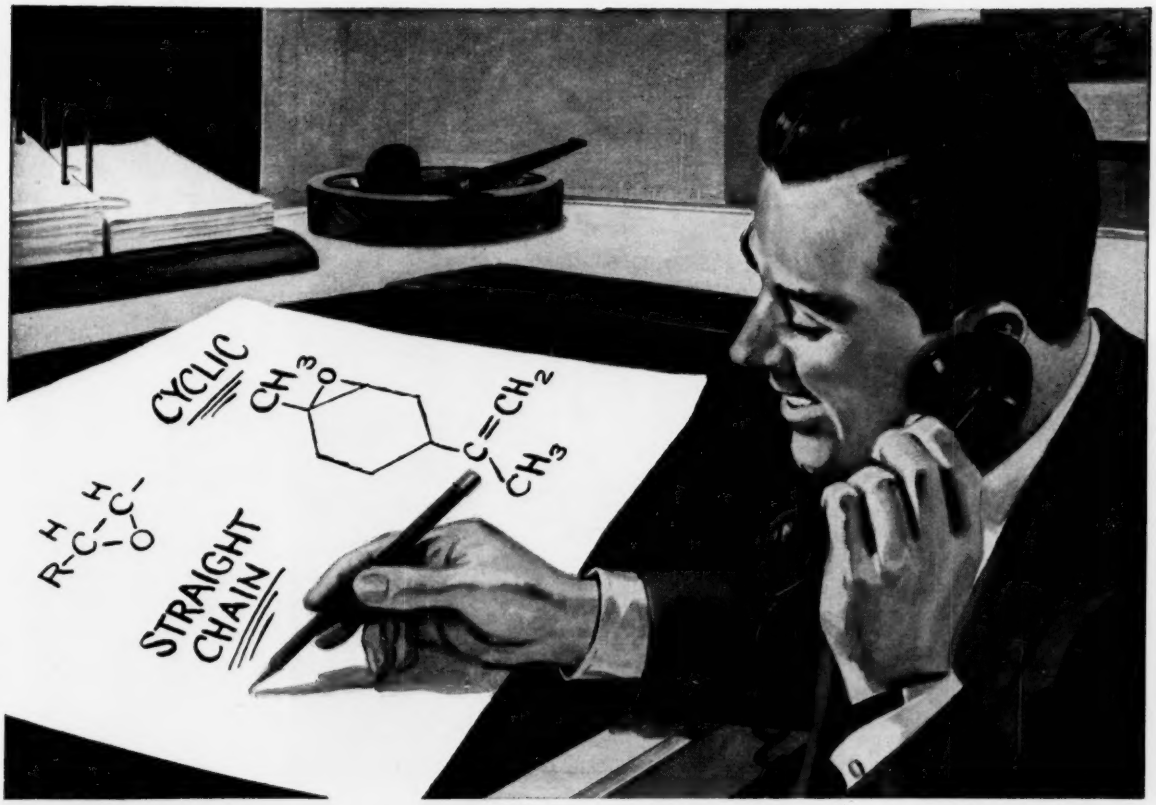
AAF — American Air Filter COMPANY, INC.

326 Central Avenue, Louisville 8, Kentucky
American Air Filter of Canada, Ltd., Montreal, P. Q.

— BETTER AIR IS OUR BUSINESS —

Air Filters and Precipitators

Heating and Ventilating Units



Looking for Versatile Epoxides?

Whether you need a straight chain olefin oxide or a cyclic, terpene oxide, Becco has an epoxy chemical to fit your needs.

Becco's epoxides, available today in semi-commercial quantities, are:

OXIDE	MINIMUM ASSAY %	F.P. °C	B.P.°C (mm)	DENSITY (°C)
Octylene Oxide	95	<−50°	77°/45mm	0.830/25°
Dodecene Oxide	90	<−10°	98°/3.5mm	0.836/25°
C_{16}-C_{18} Olefin Oxide	90	<−15°	168°/37mm	0.842/25°
Limonene Monoxide	85	<−60°	75°/10mm	0.929/20°
a-Pinene Oxide	90	<−60°	62°/10mm	0.963/20°

With the exception of the very slightly soluble Octylene Oxide, these compounds are insoluble in water. All are soluble in most organic solvents.

The three Becco olefin oxides give you your choice of chain length and reactivity of a terminal or internal epoxide group. Limonene Monoxide (Dipentene Monoxide), combining the reactivity of an epoxy group with that of an olefinic double bond in a cyclic terpene molecule, undergoes the usual reactions of *both* groups. And, in Becco *a*-Pinene Oxide, the bicyclic nature of *a*-pinene is combined with an epoxy group for unusual reactivity.

These interesting epoxides are used as reactive diluents in epoxy resins. Other applications in plastics and coatings are being actively investigated.

For samples and additional information, write for Becco Bulletins Nos. 72, 73, 74, 81 & 82. Watch, too, for new mono- and diepoxides now under development in Becco's research laboratories.

Progress in Peroxygens

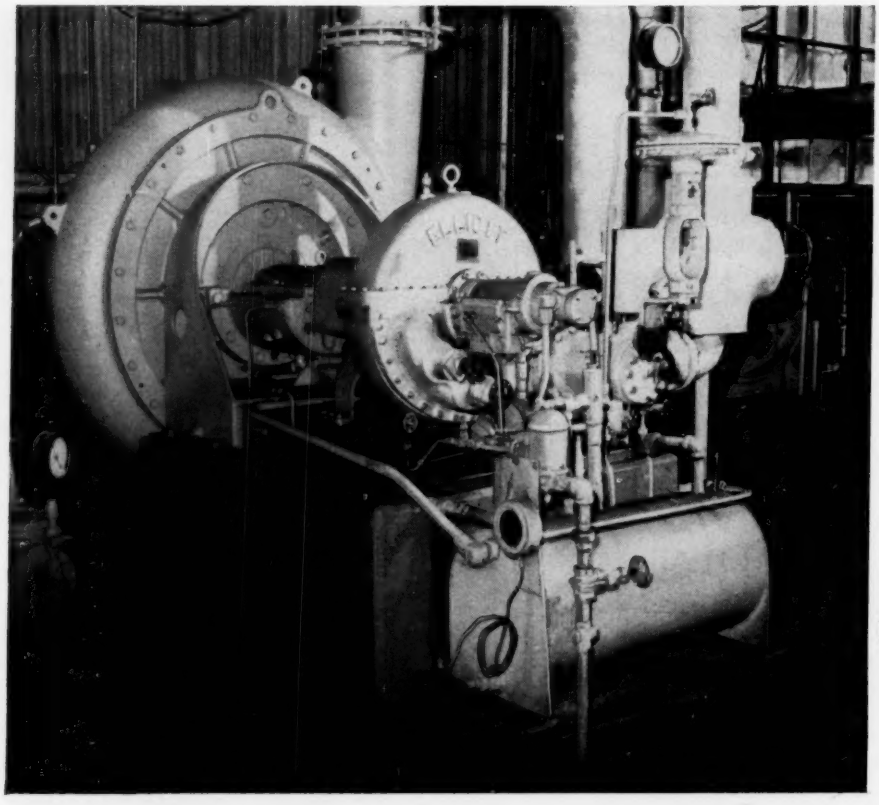
BECCO CHEMICAL DIVISION

BECCO®

Food Machinery and Chemical Corporation
Station B, Buffalo 7, New York

fmc FOOD MACHINERY AND CHEMICAL CORPORATION ®

FMC CHEMICALS INCLUDE: BECCO Peroxygen Chemicals • WESTVACO Phosphates, Barium and Magnesium Chemicals • WESTVACO Alkalis, Chlorinated Chemicals and Carbon Bisulfide • NIAGARA Insecticides, Fungicides and Industrial Sulphur • OHIO-APEX Plasticizers and Chemicals • FAIRFIELD Pesticide Compounds and Organic Chemicals



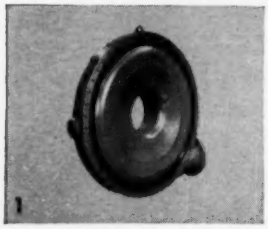
Operating day and night since 1951, this Elliott compressor is rated 12,400 inlet cfm and is driven at 4500 rpm by an Elliott 210-hp turbine.

ELLIOTT turbine-driven, single-stage Centrifugal Compressors

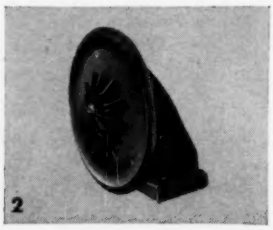
The fact that Elliott compressors are designed for long life and high operating efficiency is demonstrated by the compressor shown above, handling flue gas in a dry-ice plant. It runs 24 hours a day, and since 1951 it has been taken out of service only one day per year for routine attention.

Elliott makes a complete line of single- or multi-stage centrifugal compressors, turbine or motor drives, for handling air or gases. Ask your nearby Elliott district office for descriptive bulletin P-7 or write Elliott Company, Centrifugal Compressor Department, Jeannette, Pa.

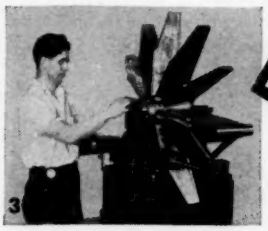
These 3 design features insure continuous trouble-free service.



Casing and inlet connection normally made of cast iron are simple and rugged. When operating conditions require it, they can be made of steel or non-ferrous alloys.



Backplate with impeller, which is mounted with a taper bore and held securely in place with a stud and crimp washer. Machined surfaces insure maximum efficiency.

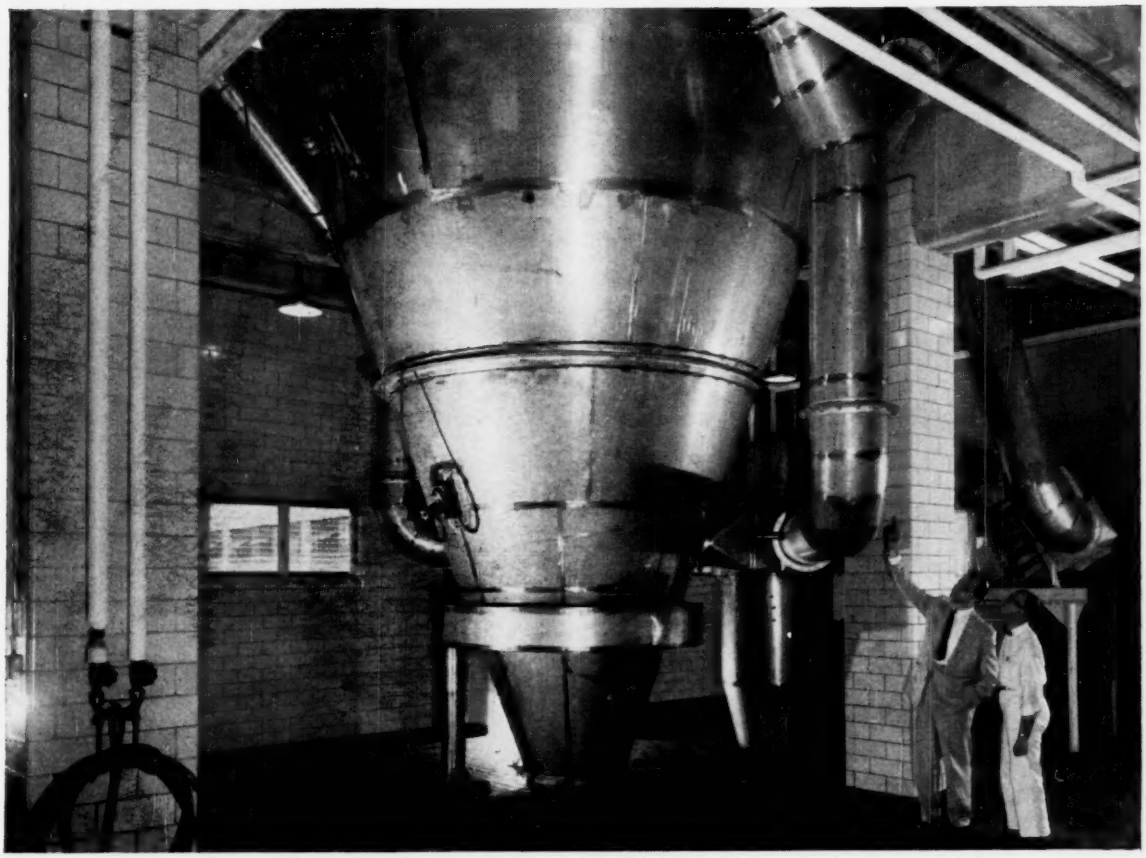


The one-piece cast steel open-type radial bladed impeller is carefully balanced both statically and dynamically before assembly on shaft. All blade junction points have smooth fillets.

ELLIOTT Company

STEAM TURBINES • MOTORS • GENERATORS • DEAERATING HEATERS • EJECTORS • CONDENSERS
CENTRIFUGAL COMPRESSORS • TURBOCHARGERS • TUBE CLEANERS • STRAINERS

P7-1



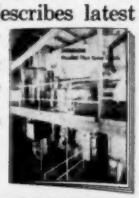
For Kroger's Instant Coffee . . .

A RICH, FRESH, CONSISTENT FLAVOR

Swenson Spray Dryers consistently deliver product with the flavor, particle size, color and density that Kroger demands for its top-notch soluble coffee. The Swenson air distribution head minimizes air turbulence . . . prevents powder build-up . . . eliminates frequent wash-downs and powder loss that could eat up profits. The Swenson design also produces more soluble coffee from a given amount of extract by means of an efficient collector system.

Swenson serves all the process industries—with evaporators, dryers, crystallizers, filters, pulp washers and condensers. Call on Swenson's broad engineering experience, integrated manufacturing facilities and extensive field service to meet your needs.

WRITE FOR "SWENSON PARALLEL FLOW SPRAY DRYERS" Here is a new 8-page booklet (illustrated in full color) that describes latest developments in efficient spray drying techniques. Send today for your copy. *Swenson Evaporator Company, 15669 Lathrop Avenue, Harvey, Illinois.*



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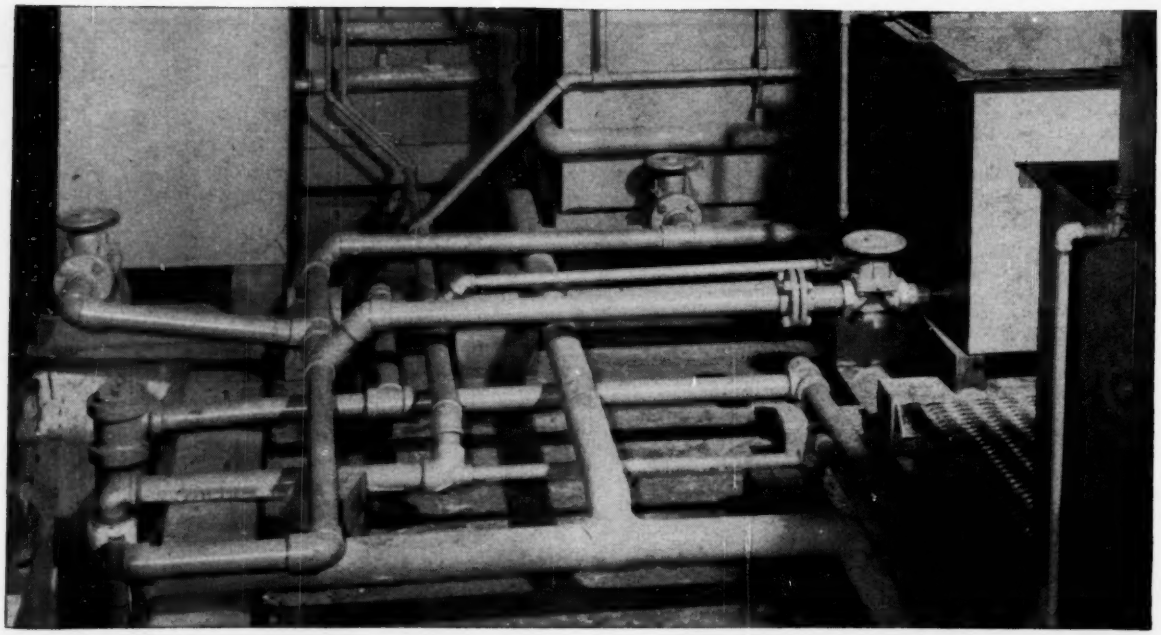
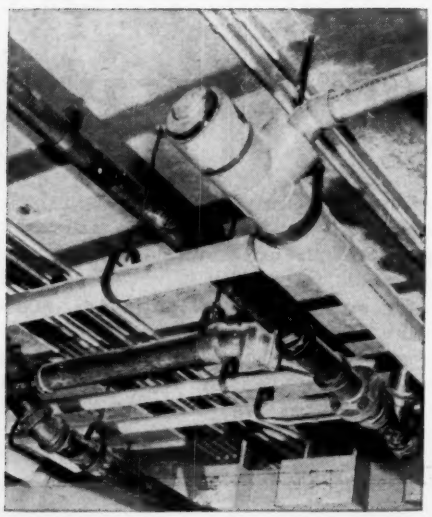
WHITING: MANUFACTURERS OF CRANES; TRAMBEAM HANDLING SYSTEMS; TRACKMOBILES; FOUNDRY and RAILROAD EQUIPMENT



Muriatic acid lines of USS National PVC Pipe

used at National Lock Fastener Plant



The National Lock Co. Fastener Division, Rockford, Illinois, is using 3,000 feet of USS* NATIONAL Polyvinyl Chloride Pipe in sizes from 1" to 4" O. D. to convey muriatic acid, deionized water and acid wastes for their plating process. Their choice was dictated by USS NATIONAL* PVC Pipe's immunity to acids and corrosion, and its excellent economy.

Two types of USS NATIONAL PVC Pipe are available:

Normal Impact—for installations requiring the highest chemical resistance attainable, together with high strength and excellent creep resistance.

High Impact—for installations requiring excellent chemical resistance and a high degree of toughness, even at low temperatures.

USS National PVC Pipe comes in sizes from ½ inch to 14 inches in diameter, and in Schedules A, 40, 80 and 120.

National Polyvinyl Chloride Pipe has a variety of uses in the chemical industry because it is resistant to many chemicals, including acids, alkalies, salt solutions and alcohol.

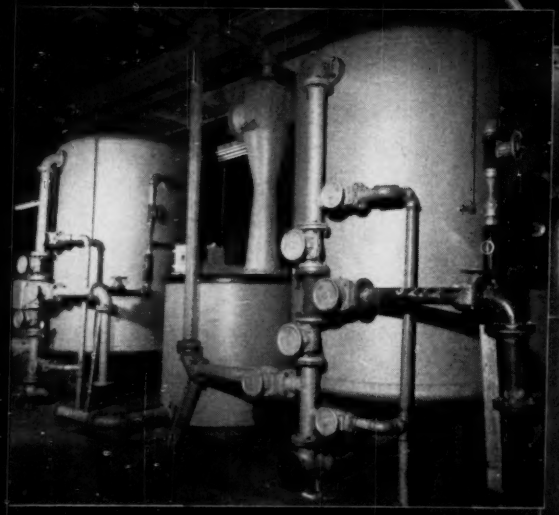
If you'd like more information, write to National Tube Division, United States Steel Corporation, 525 William Penn Place, Pittsburgh 30, Pa. Ask for Bulletin No. 24.

"The world's largest and most experienced manufacturer of tubular products— NATIONAL TUBE"

National Tube Division of United States Steel

*TRADEMARK

Columbia-Geneva Steel Division, San Francisco, Pacific Coast Distributors • United States Steel Export Company, New York



EXAMPLE 1: *REMOVAL OF INORGANIC CONTAMINANTS*—INDUSTRIAL dual cation exchange unit operating on the hydrogen cycle. Unit is stainless steel and explosion-proof. Removes inorganic contaminants from an ether solvent carrying an organic intermediate product. Process improves quality of the final product.

EXAMPLE 2: *PREPARATION OF PHARMACEUTICALS*—INDUSTRIAL Ion Exchanger removing metallic impurities (lead, iron, etc.) from ascorbic acid (Vitamic C) in the sodium cycle to improve purity and obtain more uniform product.

INDUSTRIAL ION EXCHANGERS

meet highest purity standards for continuous processes

Every day INDUSTRIAL Ion Exchangers are *replacing* expensive, complicated processing equipment in the purification of literally hundreds of chemical products. Why? Because INDUSTRIAL has successfully adapted the newest developments in ion exchange research to simple techniques. This new equipment provides advantages like these: NO HOLD-UP TIME . . . LOWER CAPITAL INVESTMENT . . . LOWER OPERATING COSTS . . . PLUS—PURITY STANDARDS TO MEET VIRTUALLY ALL REQUIREMENTS!

The operating simplicity of these new techniques permits immediate integration of an INDUSTRIAL Ion Exchanger in almost any continuous chemical process. The views on this page show some current specialized applications.

Investigate how INDUSTRIAL Ion Exchange equipment can solve your purifying problems at lower costs. Call or write today for details covering an analytical economics study.

INDUSTRIAL

C-258

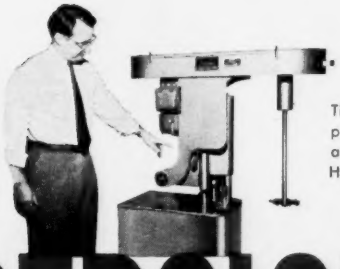
INDUSTRIAL FILTER & PUMP MFG. CO.

5918 Ogden Avenue, Chicago 50, Illinois

PRESSURE FILTERS ◆ ION & HEAT EXCHANGERS ◆ WASTE-TREATING EQUIPMENT

COWLES SETS DISPERSION VOLUME RECORDS

multiplies output per hour, in less space and less time—at less cost



Tip-up type for pilot plants and small production. Highly versatile **5-VT.***

The big-volume and high efficiency records of the Cowles Dissolvers are rapidly making these advanced machines all-around workhorses of chemical production. While the Cowles actually provides up to 20 times faster mixing action—it is simpler to operate, takes less space than conventional equipment. And with records of up to several times the hourly volume of ordinary mixers, it operates with low maintenance requirements—and even lower initial cost. In all models, uniform results in high quality end products are completely proved.

Versatility is unchallenged for gas-liquid, liquid-liquid and solid-liquid applications such as:

ULTIMATE DISPERSION. Breaks material down to ultimate particle size, quickly surrounding each particle with a film of liquid.

EMULSION. Creates fine, extremely stable emulsions of the most difficult types, without pumps, targets or auxiliary equipment.

WASHING & EXTRACTION. Picks up dense materials from tank bottom, imparts intense washing and scrubbing action. Result: shorter and fewer cycles, more efficient use of scrubbing component, better operation of evaporators, filters, etc.

REACTION. Acts efficiently in producing small crystal sizes. More efficient utilization of reactants gives higher yield, particularly in gassing operations. Speeds reactions, simplifies temperature control.

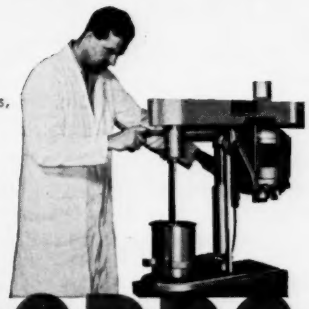
The first with variable speed for big batches. **510-VHV** hydraulic lift unit.*

Key to efficiency: the "Multi-Phase" action of revolutionary Cowles Impeller

This unique, patented impeller takes materials through several action phases not produced by ordinary equipment. Material is thrown off at 60 mph speed from impeller vanes. Particle is thus sheared and smashed against particle in a zone of intense "hydraulic attrition." At the same time, the entire batch is kept in "total motion," returning to the impeller in a controlled cycle. Scientific details on request.

Fastest growing popularity in its field

Cowles "multi-phase" action is setting new production records throughout the industry. Enjoy its benefits now. Let us prove the Cowles in your plant—at our risk. Write or send coupon today for complete details.



For laboratories and pilot runs, **1-VG** gives results identical to large models.*

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Please send complete details on the Cowles for production of _____

☐ *Am interested in a trial installation.*

Name _____ Title _____

Firm _____

Address _____

City _____ Zone ____ State _____

5717

Typical Cowles Dissolvers. Choose from many models.

Simplicity in steam traps can effect big savings in parts inventory and maintenance time

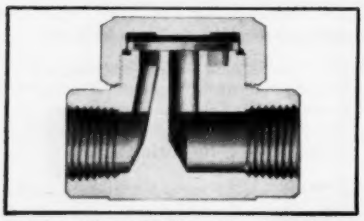
by John W. Ritter, Test Engineer
SARCO Company, Inc.

The function of all steam traps is to release condensate and prevent steam loss. However, the method of trapping can make a great difference in cost and effectiveness.

In the Sarco Thermo-Dynamic Steam Trap, the method is fundamental. Air or condensate entering the trap must flow from the inlet tube, radially across the underside of the disc valve, to the outlet. The space between the inlet tube and the disc forms a nozzle in which the static pressure energy of the incoming fluid is partly changed to velocity across the underside of the disc, with a resultant *decrease* in pressure. (This will be recognized, of course, as the Bernoulli Principle.) Use of this fundamental method means reliability in operation.

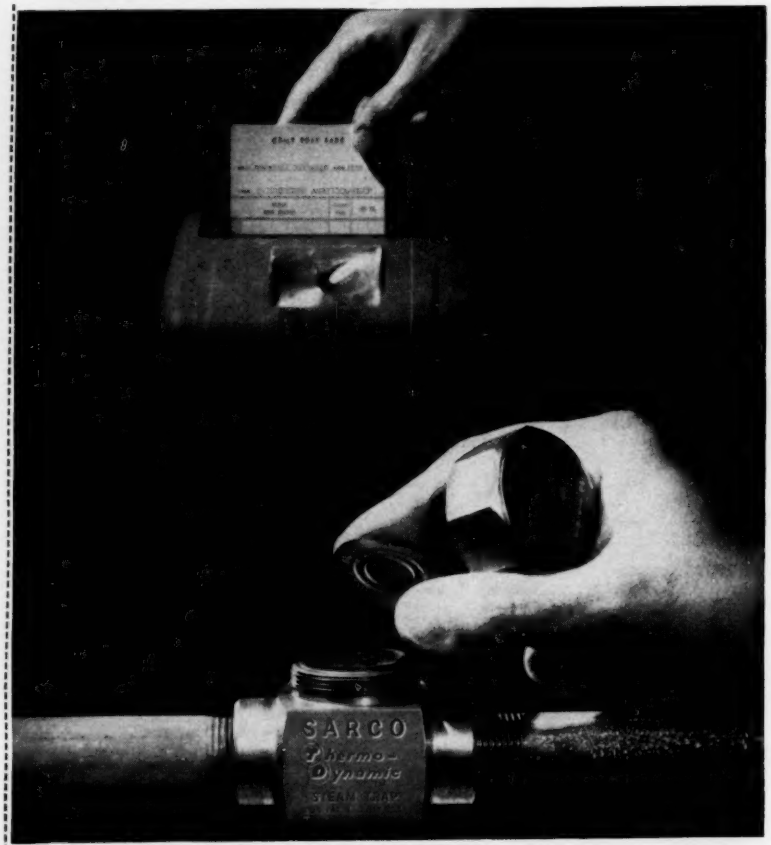
As the high velocity fluid jet strikes the side of the upper chamber, some recompression takes place, so that the pressure above the disc becomes greater than the pressure below it. The pressure reduction under the disc and the pressure recovery above it depend on the internal energy of the fluid. As the condensate above nearly approaches steam temperature, its internal energy is enough to overcome the upward force at the inlet tube and the disc snaps down in the inlet tube, which is the inlet valve seat.

Simultaneously, the disc also seals the outer ring, which isolates the space above the disc from the outlet. The disc valve is therefore held firmly against the inlet valve seat until the pressure in the control chamber is reduced by condensation. The upward force then exceeds the downward force and the disc valve opens.



This 3-part Sarco TD Steam Trap has only one moving part—the hardened, polished stainless steel disc.

No other trap uses the velocity of the fluid to operate the valve or uses the recompression of the flowing fluid to trap the valve closed and to hold it closed. When it closes, it closes tightly – no "operating steam" leaks out.



40 seconds inspection time— that's all it takes for a SARCO TD Steam Trap

Just back off the cap of a Sarco TD. Lift out its single moving part, the stainless steel disc. Wipe it off, and drop it back. No adjustment is ever required, at any load or any pressure in its range – from 10 through 60 psi.

The TD operates in any position, won't blow steam at any load. Small as a tee fitting, it can be installed in tight places. Its versatility and reliability cut cost of big replacement inventory.

Write for "Literature Kit 2A" today and get latest bulletins on the TD Steam Trap and other Sarco steam traps. Remember that Sarco can give you impartial advice on *Production Planned steam trapping* because . . .

5605-B

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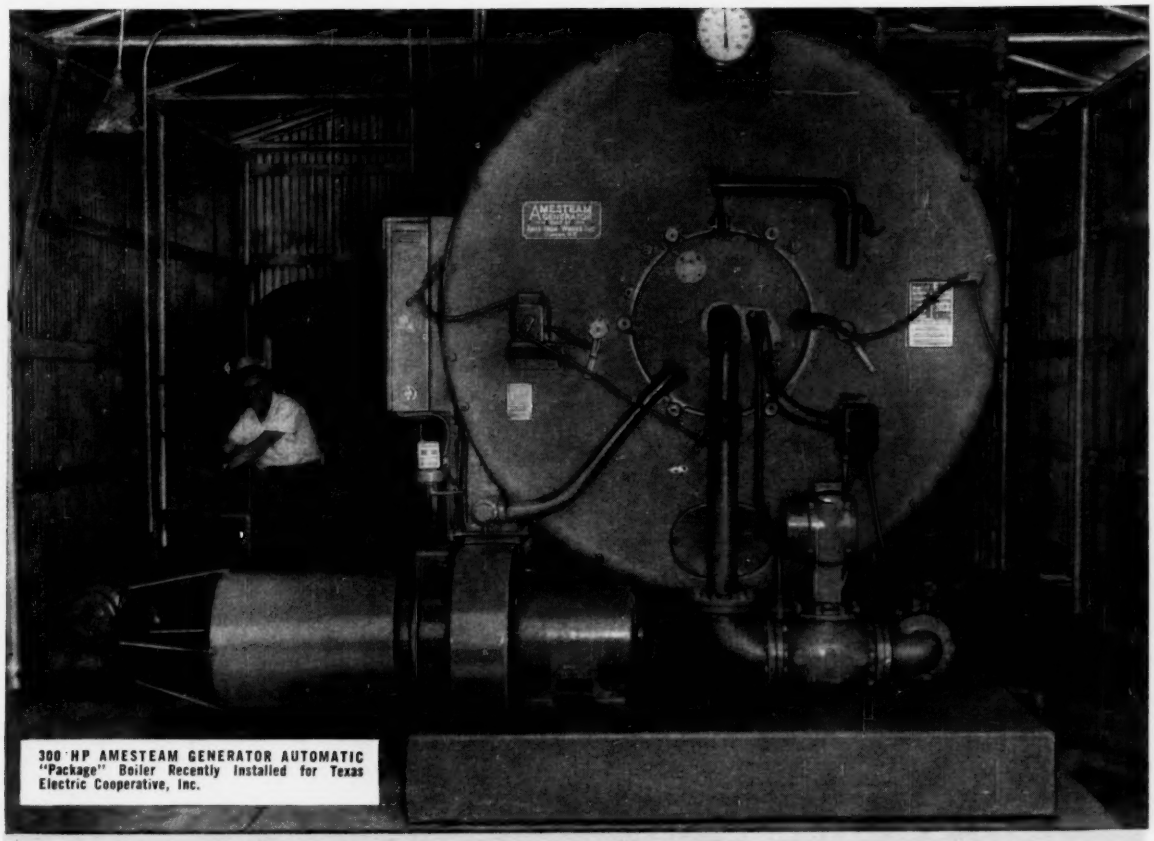
COMPANY, INC.
635 Madison Ave., New York 22, N. Y.

Only Sarco makes all 5 types:
Thermostatic • Liquid Expansion • Float Thermostatic
Thermo-Dynamic • Bucket

STEAM TRAPS • TEMPERATURE CONTROLLERS • STRAINERS • HEATING SPECIALTIES



300 HP AMESTEAM GENERATOR AUTOMATIC "Package" Boiler Recently Installed for Texas Electric Cooperative, Inc.

TEXAS ELECTRIC COOPERATIVE, INC.

Cuts Fuel Consumption Over 36%
Saves Over $15,000 per year
...with AMESTEAM GENERATOR

We Quote the Money-Saving Facts:

"We were very pleased when we replaced two gas-fired boilers in our presssure testing plant with one new 300 HP AMESTEAM GENERATOR Automatic "Package" Boiler. The new Ames unit has reduced our fuel costs alone by 38% ...a saving of *$7,800 per year.*

"Because our new AMESTEAM GENERATOR is entirely automatic, three firemen are now transferred to other duties. This results in an additional saving of *$7,200 per year.*

"This total saving of *$15,000 per year* does not include the considerable savings in maintenance costs. On top of this, the new Ames installation increases our production potential by 20% to 30%... with much higher quality steam."

We at Ames continually receive letters like this from the enthusiastic users of AMESTEAM GENERATORS. Ames customers are *satisfied* customers. They know that when they buy AMESTEAM GENERATORS, they buy LOWER-COST STEAM!

What's **Your** Steam Problem?

If you need 10 to 600 HP and want the kind of space-saving, trouble-free service enjoyed by satisfied users of AMESTEAM GENERATORS, contact your nearby AMESTEAM Dealer or write for our Catalog.

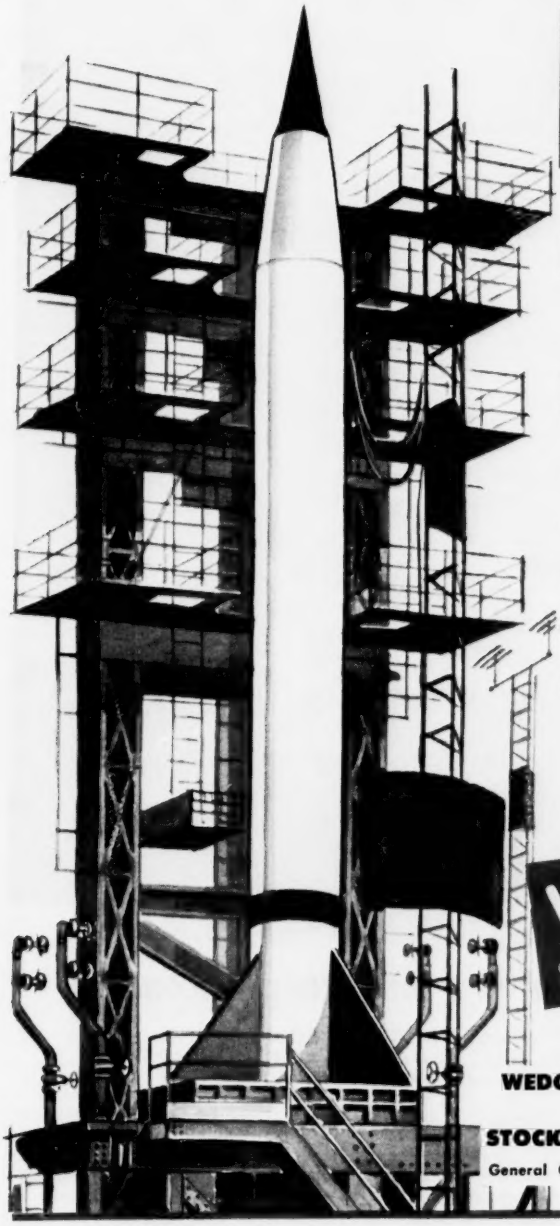
AMES IRON WORKS INC.
BOX S-68, OSWEGO, N. Y.

AMES IRON WORKS
BOX S-68, OSWEGO, N. Y.

Gentlemen:
Please send me further information on AMESTEAM GENERATORS and name of nearest representative.

NAME .....
COMPANY .....
ADDRESS .....

THE VALVE WITH A FUTURE



- In the CHEMICAL INDUSTRY
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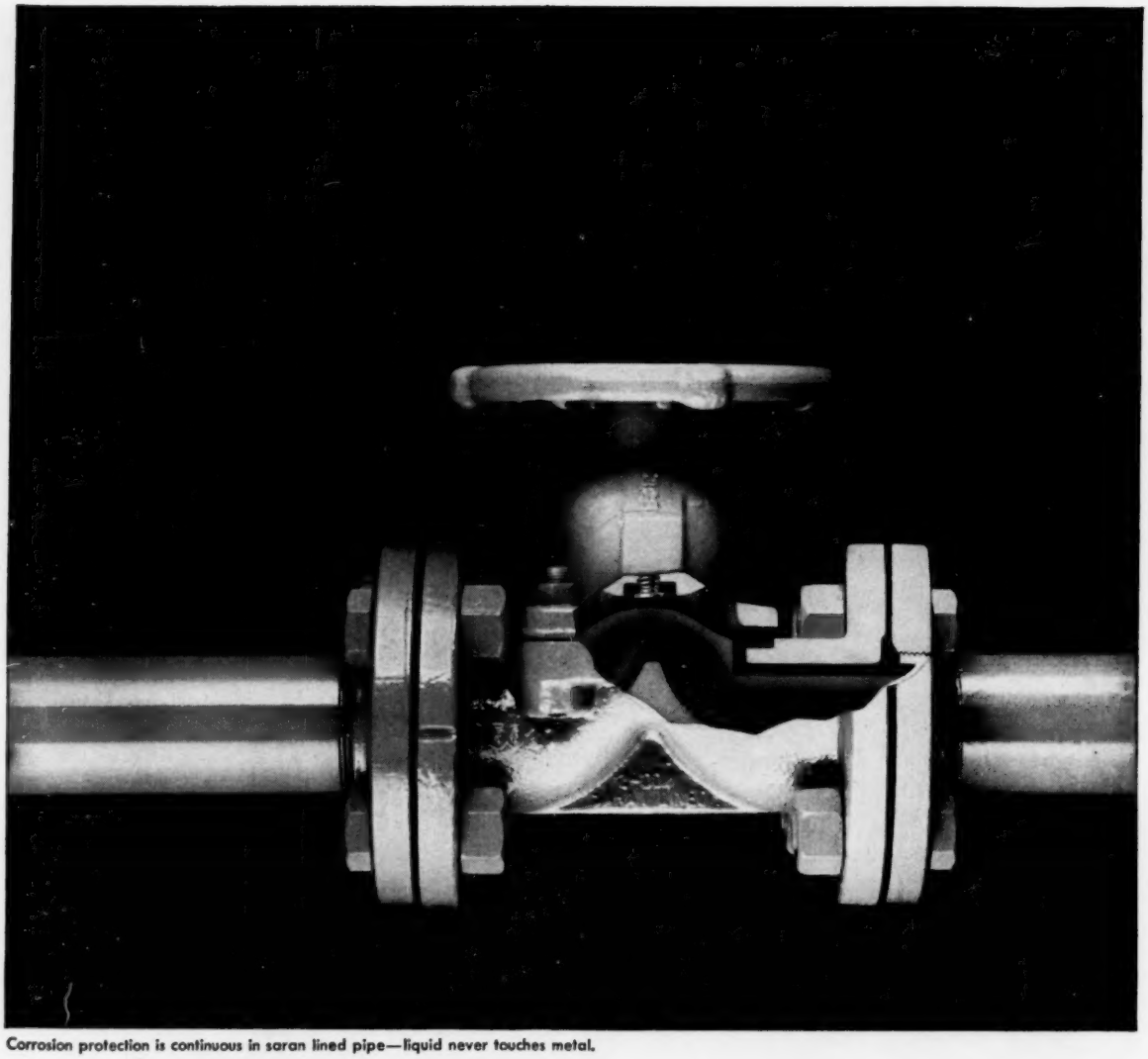

Corrosion protection is continuous in saran lined pipe—liquid never touches metal.

Here's why Saran lined pipe offers long range economy

It's rigid steel pipe . . . lined with corrosion-resistant saran . . . keeps shutdowns to a minimum for years

Looking ahead? Do your plans call for a complete corrosion-resistant piping system with a low total installation cost . . . a system that requires a minimum of maintenance . . . that's simple to modify . . . that can be fabricated in the field?

Then it will pay you in every way to look into the genuine economy of a complete system of saran lined pipe.

First, consider the natural advantages of the new gray saran lining itself. Its lower coefficient of thermal expansion and contraction more closely approaches that of steel. This provides a broader operating temperature range and greater resistance to thermal cycling. It can be installed in systems with operating pressures from full vacuum to 300 p.s.i. and temperatures up to 200° F. Add to these advantages the immediate availability of saran lined pipe, valves, pumps and fittings and you have an ideal piping system that can be installed without trouble, waiting or hidden costs.

If your plans call for lined tanks, you'll want the advantages of Saraloy® 898 tank lining added to your saran lined pipe system. Get the complete story on how it will pay you to install a complete saran and Saraloy 898 lined system. THE DOW CHEMICAL COMPANY, Midland, Michigan.

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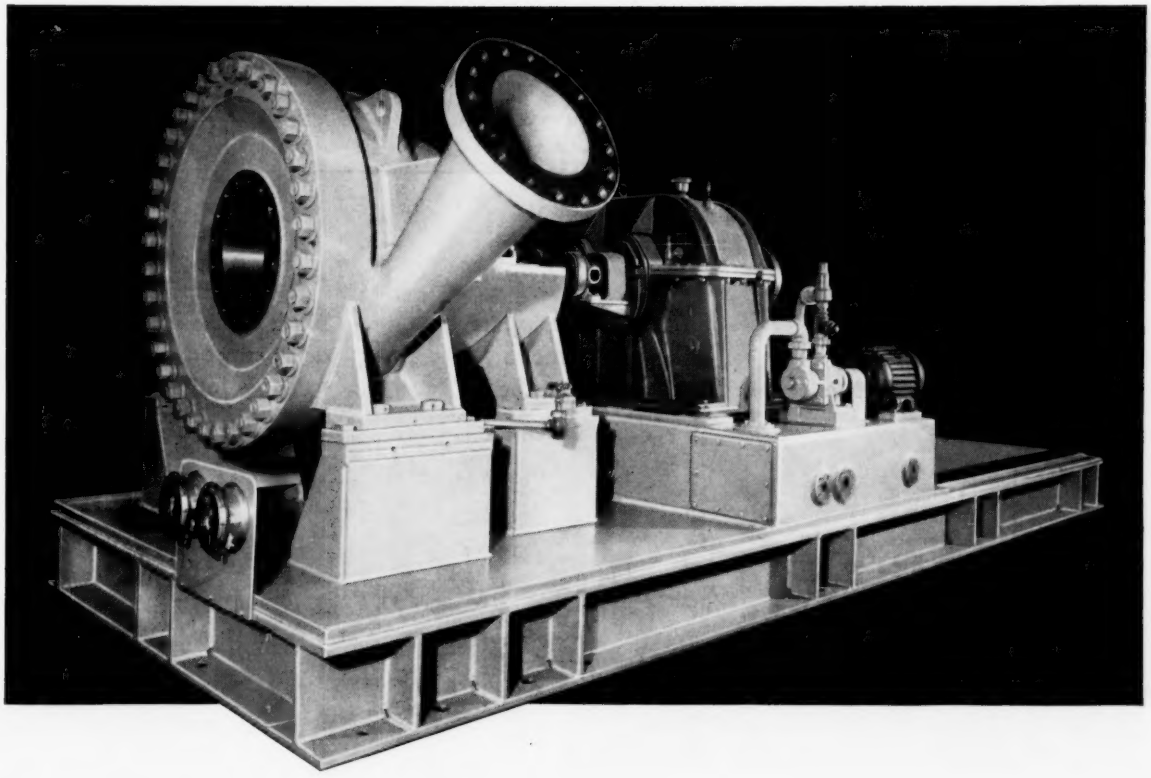

NEW

Single-Stage Barrel-Type
Allis-Chalmers Compressor

Boosts High Pressure Gas to Higher Pressure Levels in Range of 50 to 500 psia.

THIS new Allis-Chalmers development extends the range of single-stage compressors into high pressure levels previously handled by reciprocating type units.

The new compressor has all the advantages of a centrifugal compressor — compactness, pulsation-free operation, few wearing parts, easy maintenance.

The unit shown above, now in successful operation, boosts 3690 cfm of air from an inlet pressure of 185 psia to a discharge pressure of 240 psia. It is driven through a speed-up gear by an Allis-Chalmers 1250-hp motor.

The casing consists of three principal parts: the casing cylinder, a bolted casing head and a fabricated casing pedestal. A diaphragm which forms the gas diffuser passage is inserted into the casing cylinder. Excellent gas sealing is assured, since there is only one shaft extension and only one casing joint to seal against gas pressure.

For details, including a sectional view of this new compressor, call your nearby A-C representative, or write Allis-Chalmers, Industrial Equipment Division, Milwaukee 1, Wisconsin.

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A-5728

PRACTICE . . .

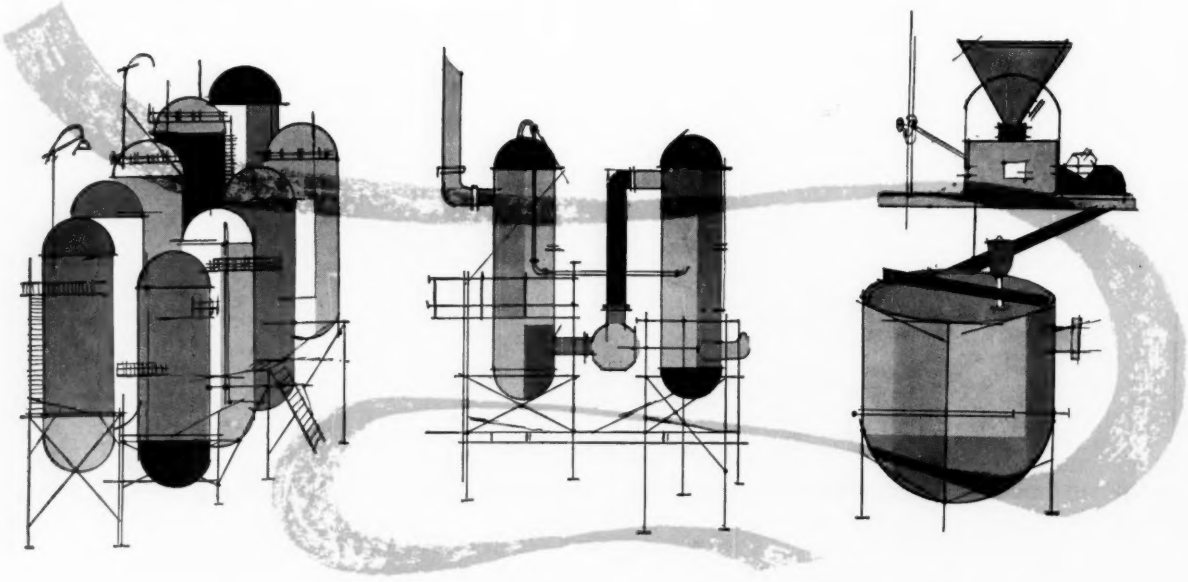
PROCESS FLOWSHEET

C. H. CHILTON

Reactors in series polymerize butadiene and styrene

Falling-film strippers efficiently remove unreacted butadiene

Black masterbatch step adds carbon black to coagulating latex



Continuous copolymer process hinges on three key steps, boasts latest in process advances and instrumentation

Continuous Rubber Route Dons a New Look

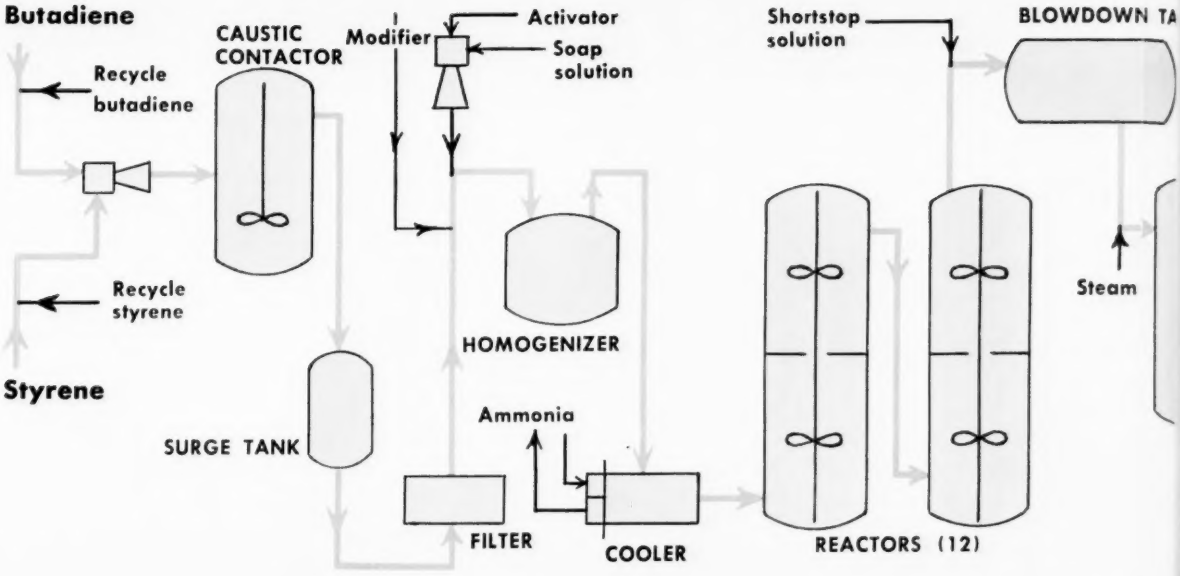
Months before Paris unveiled the sack dress or Detroit launched its latest swept-wing tailfin, chemical process designers in Akron were putting the fine lines on the newest look in synthetic rubber plants: General Tire & Rubber Co.'s $10-million, 40,000-ton/yr. plant at Odessa, Tex.

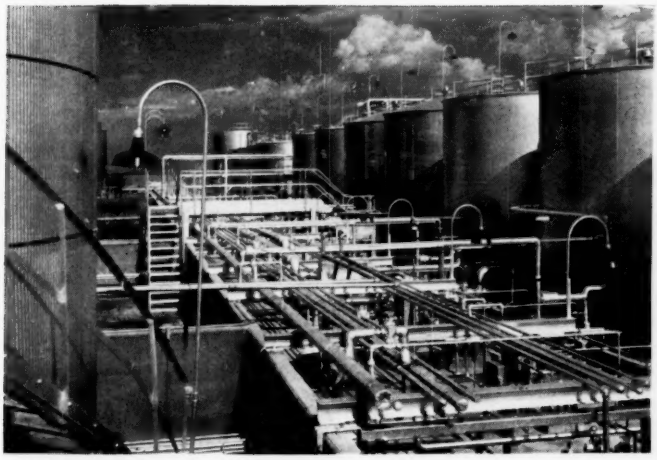
Swung on stream late last year, General Tire's continuous styrene-butadiene rubber (SBR) plant is the first such operation to be designed and built from the ground up as an integrated setup for continuous polymerization. Thus, in addition to interesting process highlights, it boasts such attractions as completely different, highly efficient plant layout and maximum use of instrumentation. This stands in sharp contrast to older synthetic plants built during the war.

▶ **Modern Look** — Plant layout incorporates vastly improved process equipment, efficiently combines areas of similar operations. Also considered part of the layout are El Paso Natural Gas's adjacent styrene and butadiene plants which pipe raw materials to the site. Instrumented to a degree unknown in previous synthetic rubber plants, General Tire's setup uses 880 instruments feeding to one information center for continuous control.

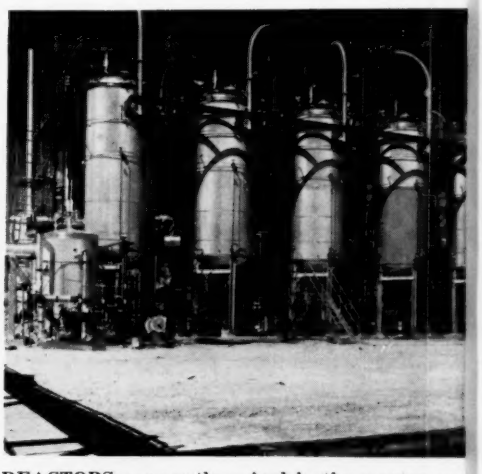
This streamlining, says General Tire, makes it possible to produce at a ton-per-man rate equal to that

Unfold Flowsheet





TANK FARM is designed for bulk storage of some of the more than 20 chemicals used in General Tire's production of synthetic rubber.



REACTORS, compactly paired in the reactor are and butadiene for polymerization, measure 20 f

of a plant four or five times as big.

▶**Process Highlights** — Resting heavily on three noteworthy key steps, the route gains much in tight process control and versatility.

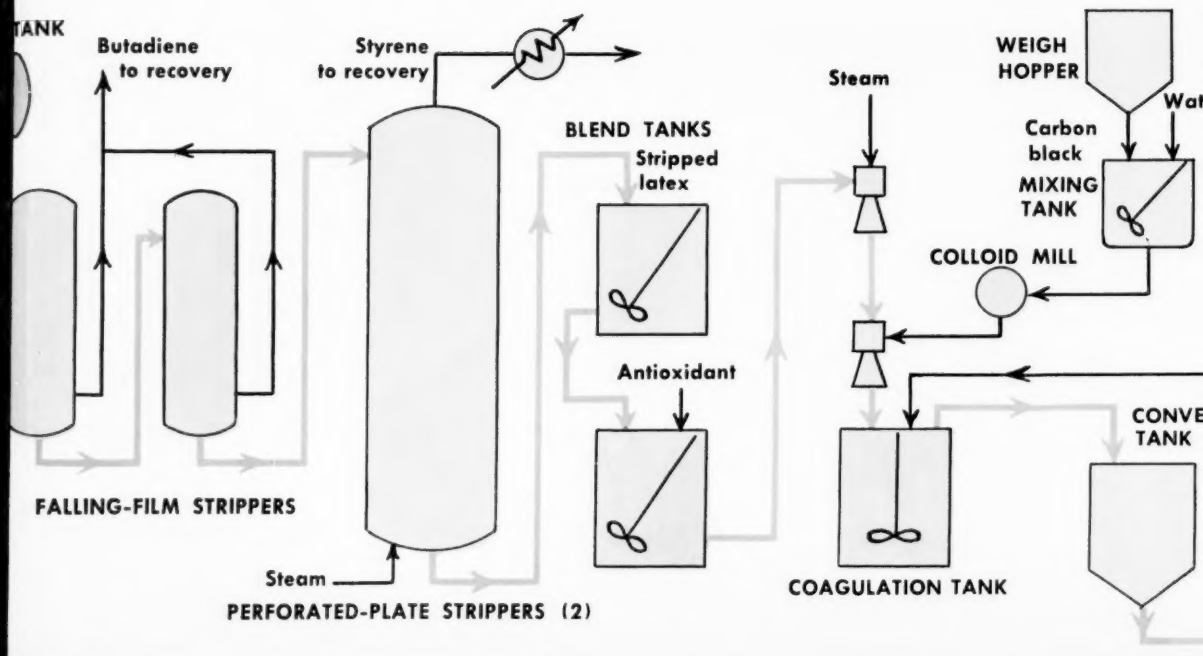
"Although this plant doesn't revolutionize the synthetic process," says General Tire's chemical head, A. L. Antonio, "we do feel that we've made process improvements which give us a competitive edge in the field."

Key process improvements include 12 series-linked continuous polymerization reactors, two falling-film butadiene strippers instead of the more common flash tanks and black-masterbatch step, designed to use Columbian Carbon's process for adding colloidal carbon slurry to latex.

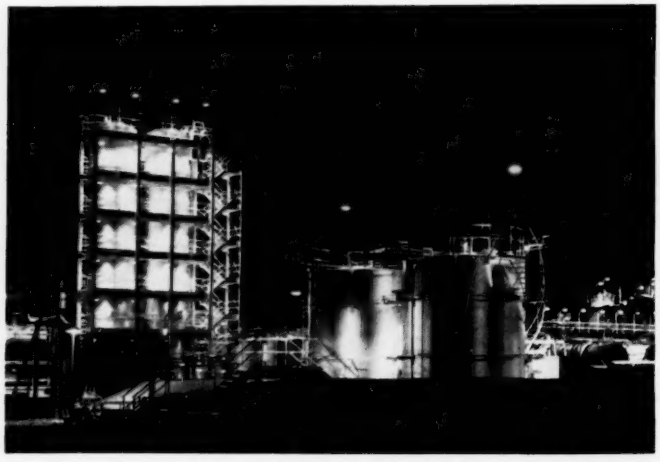
▶**Gains Advantages**—Chief advantage of falling film strippers, General Tire points out, is that they operate more efficiently at lower temperatures and with less liquid holdup than conventional flash tanks, thus give faster response and closer process control.

Black masterbatch step, now used by other rubber makers, enables rubber processors to eliminate step of adding carbon black in Banbury mixer. At this point, it's important to remember that General Tire's plant can turn out both black and white rubber via either black-masterbatch or oil-extended mixing.

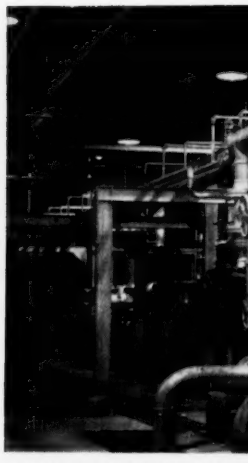
▶**How Process Works**—Fresh styrene and butadiene are piped to the plant, mixed with recycle monomer, passed through a caustic contactor for purification. Here,



rea, take pure styrene ft. high, 90 in. dia.



PERFORATED-PLATE STRIPPERS, operating at about 140 F., strip out unreacted styrene from polymerized latex, send styrene to recycle.



RECOVERY PUMP HOU takes butadiene from stri

impurities are removed via 3,000-gal. batch circulation of 20% caustic soda solution. Solution is replaced about every 15 days. A felt-type water filter removes aqueous phase.

To pure monomers are added modifier (tertiary dodecyl mercaptan), activator General Tire's own formula) and soap solution. Mixture goes through homogenizer, precooler and polymerization reactors.

Soap solution emulsifies styrene and butadiene before they polymerize. Polymerization is initiated in micelles of soap molecules which solubilize the monomers. Initiator, containing a free radical, initiates reaction; modifier controls chain length.

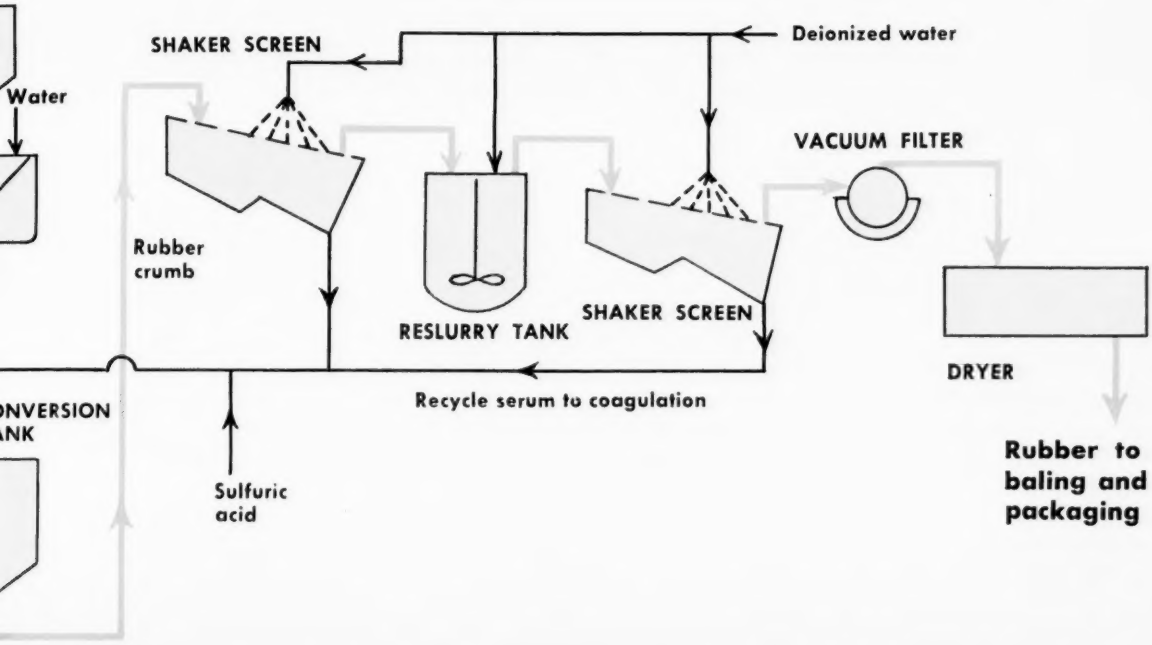
Shortstop solution, added after the last reaction stage, stops polymerization at the desired conversion.

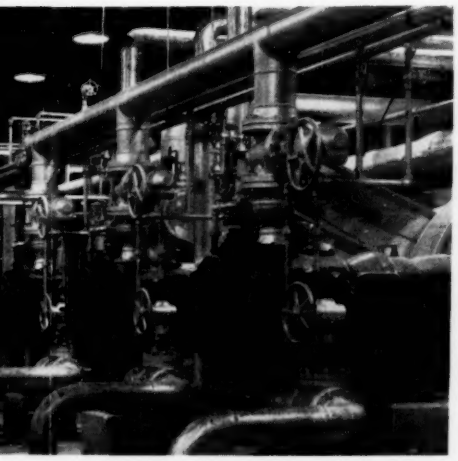
► **Versatile Reactors** — Twelve 7,000-gal. reactors, paired in a compact layout, can produce either cold SBR (40-45 F., 0-15 psig.) or hot SBR (122 F., 45-60 psig.).

Thus, the reactor system contributes solidly to the high degree of flexibility in turning out different grades of rubber.

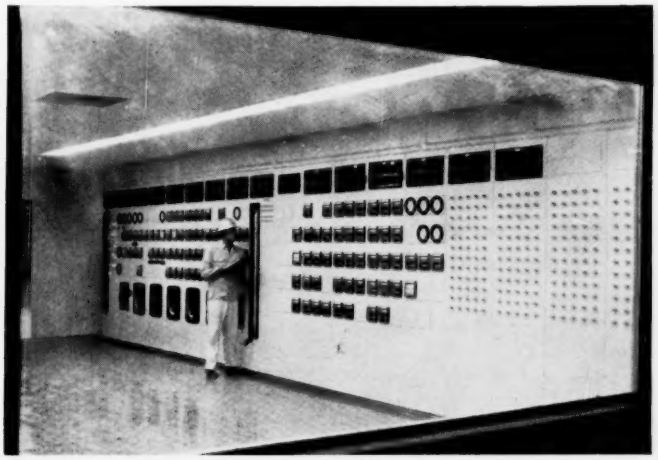
Each reactor measures 20 ft. in height and 90 in. inside dia., is divided into upper and lower sections by a central partition. Each section has its own set of ammonia cooling coils and is agitated by propellor mixers driven at 68 rpm. by a motor mounted at bottom of reactor.

Reaction residence time in each of the 12 reactors is 1.0-1.25 hr., de-





HOUSE contains butadiene recycle compressors, strippers and recycles it to purification.



CONTROL ROOM, housing information center for 880 instruments, provides means of continuous process control in making latex.

pending on production rate and number of reactors in service. (Any reactor or reactor section can be bypassed in operation.) Total cooling load for each reactor is 110 tons of refrigeration—132,000 Btu./hr.

▶**To Strippers**—Latex from reactors is gathered in a blowdown tank, pumped through falling-film strippers to remove butadiene, then through a perforated-plate stripper to strip out styrene.

First stage falling-film evaporator operates at about 80-90 F. and second stage operates at 120-125 F. Styrene recovery columns operate at roughly 140 F. Styrene and butadiene are recovered and recycled to caustic contactor.

Latex is pumped to one of five blend tanks. Antioxidant, also oil emulsifier (when used), are added to latex in a mixing tank prior to coagulation.

From here, stripped latex is pumped to continuous coagulation step where black-masterbatch technique adds colloidal carbon black. Mixture is agitated with a dilute (pH 4.0-4.5) sulfuric acid solution. Coagulating polymer overflows to conversion tank to complete formation of rubber "crumb." (With other grades of rubber, salt-water brine would also be added to coagulation tank.)

▶**Washing, Packaging** — Rubber crumb overflows onto shaker screens where impurities are washed out with deionized water and then is dried with hot air in continuous-belt dryers.

After drying, rubber is pressed into 75-lb. bales and wrapped in polyethylene film for shipping.

Part of the Permutit Precipitator-filter-demineralizer plant treating 2 million gallons of water per day at West Virginia Pulp & Paper Company, Charleston, S. C.

She's only five foot two, but she "operates" these six Permutit Valveless Filters

• If these were standard manually-operated gravity filters, it would take 3 husky well-trained men (3 one-man shifts) to open and close heavy valves for shutoff, backwash and rinse. If they were table-controlled automatic filters, the initial cost would be almost *doubled.*

Fact is these filters are in the same price range as manual filters, yet they are *completely automatic.* They shut themselves off from service at just the right bed condition. They backwash and rinse at the most efficient flow rates and for a pre-set length of time. Then they put themselves back into service. The little lady doesn't have to touch them!

Permutit Valveless Filters use a simple design employing basic hydraulic principles to do the "thinking" and the work . . . replacing expensive valves, flow controllers and hydraulic or pneumatic control systems. Initial installations have been approved for treatment of drinking water as well as process water.

Our new Bulletin No. 4351 tells how you can cut both initial and operating costs with Valveless Filters. Call the nearest Permutit man or write to The Permutit Company, Dept. **CE-6,** 50 West 44th Street, New York 36, N. Y., or Permutit Company of Canada, Ltd., Toronto 1, Ontario.

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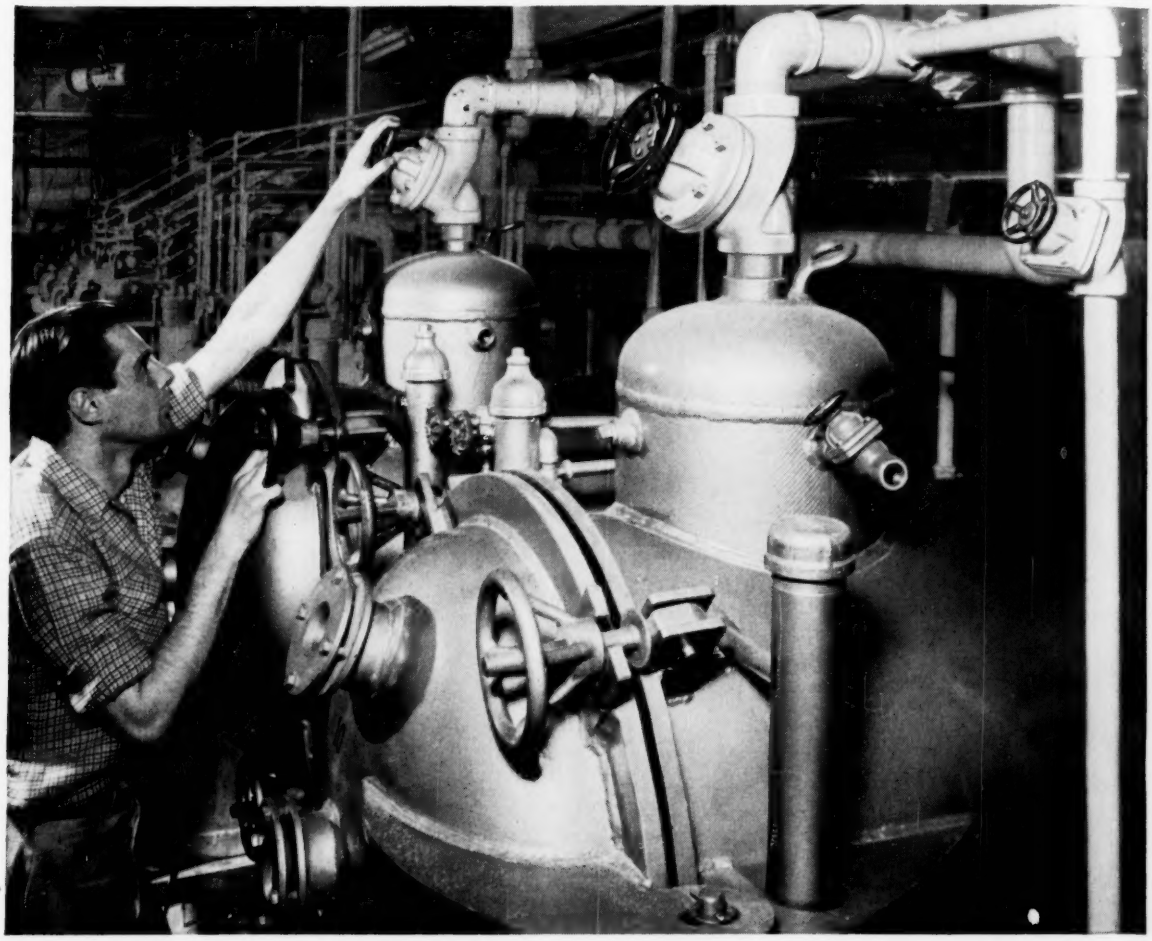


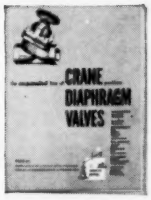
Crane diaphragm valves still hold tight after 18 months on 100-micron vacuum service

Electron Products Inc., Pasadena, Calif., forms special electronic parts of metalized paper. Processing—drying, deaerating, impregnating—is done under constant vacuum.

Valves, to hold the critical vacuum within a maximum leak rate of 100 microns for a 24-hour period during processing, had to be selected with care. Obviously not any valve would do. The choice—Crane diaphragm valves for high performance value.

After 18 months, these Crane packless valves continue to hold tight on this critical vacuum service for as long as 36 hours—and on occasion, over an entire weekend.

Crane packless diaphragm valves are widely used also in processing industries where absolute tightness is necessary to prevent leakage of volatile, corrosive and hard-to-hold fluids. Complete information is available from your Crane Representative. Or write for 24-page circular.



All about Crane diaphragm valves—patterns, body and trim materials, linings, 180 tested service suggestions, etc.—in Circular AD-1942. Send for it today.

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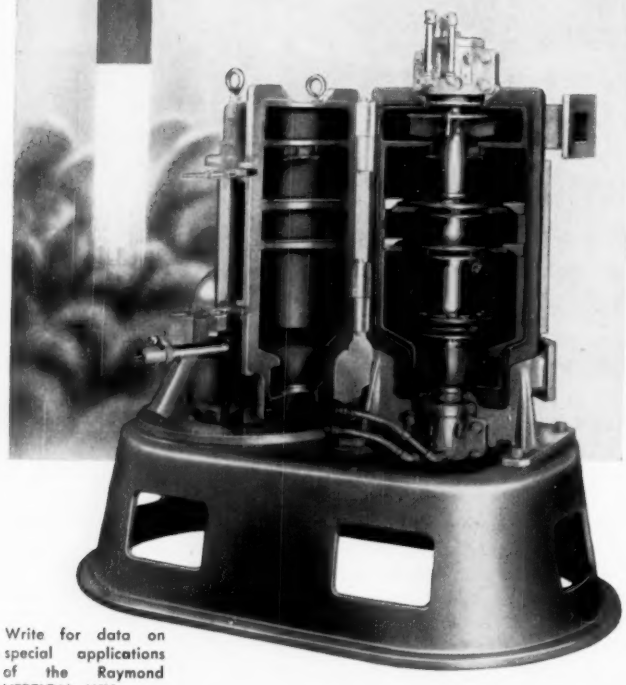
Another Exacting Job for the RAYMOND VERTICAL MILL



Write for data on special applications of the Raymond VERTICAL MILL.

Now working with industry on today's newest developments, the Raymond Vertical Mill is serving manufacturers in the production of solid rocket propellants.

Since this unit is designed for pulverizing to extreme fineness and uniformity, it does an excellent job in grinding the ammonium nitrate and ammonium perchlorate oxidizers to the required specifications.

Outstanding features of the Vertical Mill are:—

1. Ability to meet exacting particle size distribution requirements for proper burning rate and molding qualities.
2. Easily adjusted for a wide range of product fineness.
3. Quick and complete accessibility for adjustments, clean-out or maintenance.
4. Trouble-free operation with no over-heating of product.
5. Automatic and dust-free operation.
6. Compact layout and flexible installation.

One company has already been using the Raymond Vertical Mill for over two years, and has obtained excellent results on ammonium nitrate and perchlorate. Raymond mills have also been used for many years on the potassium chlorate, perchlorate, and nitrate oxidizers.

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Department Index

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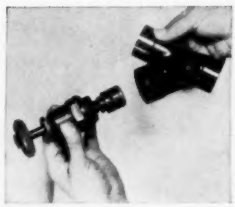
licks 281 corrosives

Lab tests have shown that versatile Ryertex®-Omicron PVC will resist 281 corrosive solutions and gases . . . including acids, alkalies, waste products, etc. If you have a corrosion problem, a Ryerson specialist can quickly tell you whether Ryertex-Omicron PVC is your answer.

This remarkable plastic has advantages beyond corrosion resistance, too. It is light in weight . . . tough, immune to weathering, rotting or aging. It is non-combustible, non-magnetic, non-sparking . . . and in many applications Ryertex-Omicron has been used successfully at operating temperatures up to 200°F. It's available for quick delivery in pipe and fittings, sheets or rods. For specific application information, call your nearby Ryerson plant.

Typical applications of PVC

Process piping, tanks, tank linings and troughs, filtration units, fan housings, fume systems, conveyors, agitators, settling towers, scrubber towers, neutralizing acid equipment.



Pipe. From ½" to 12" in diameter. Valves, flanges, and fittings to match.

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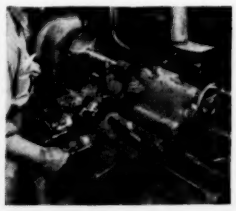

Rods. Round machining stock from ¼" to 2" in diameter. Welding rods also.

PVC forms easily, cuts with a handsaw, welds like metal, machines on standard equipment. Pipe can be joined by brushing on solvent and applying fitting. Call your nearby Ryerson plant today—ask for illustrated Ryertex-Omicron PVC Bulletin 80-3.

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Happy Birthday A.I.Ch.E.!

Later this month historic old Philadelphia again becomes the center of the chemical engineering world. It was there on June 22, 1908, that a brave little group of 40 pioneers in a new and unrecognized profession met and formally signed their declaration of independence. Now, 50 years later, their successors will return by the thousands to celebrate the golden jubilee of the organization they so ably founded there—the American Institute of Chemical Engineers.

On behalf of all chemical engineers the world over who have benefitted from the labors and far-seeing vision of its founders and all who have contributed, ever so humbly, to its half-century of outstanding progress, this magazine's staff members of AIChE want to say "Happy Birthday!" May the Institute continue to grow in strength and influence as it speaks with an ever firmer voice for the future of the chemical engineering profession.

W. L. Parmelee
AIChE National Secretary, 1927-29.

Sidney D. Kirkpatrick
AIChE National President, 1942.

John R. Callaham · James A. Lee · Cecil H. Chilton · C. S. Cronan
Raymond F. Fremed · Robert B. Norden · J. Peter Jacobsen · E. J. Mikity
Roland A. Labus · J. H. Arnold Jr. · Charles C. Van Sicklen · John A. King
Paul W. Cobb · Hugh G. Sloan · J. Elton Tuohig

YESTERDAY

Engineering Societies Building, in New York, was made possible through a gift from Andrew Carnegie to the four "Founder Societies." Started in the spring of 1906 it was occupied by December of that year. It has been outgrown for many years.

Cornerstone of the Engineering Societies Building was laid on May 6, 1906, with Andrew and Mrs. Carnegie and daughter among those at the ceremony.

TODAY a Foundling Among

IN 1906 the generosity of the late Andrew Carnegie made possible the construction of the Engineering Societies Building at 29 West 39th St. in New York. What chemical engineering there was in those early days was most often regarded as a curious hybrid of chemistry and engineering—unclaimed and unhonored by either of its parents. Two years later, however, an infant organization was started, calling itself the American Institute of Chemical Engineers. Some jokingly described it as a "foundling" left on the doorstep of the *four* so-called "Founder Societies."

On this 50th anniversary of AIChE—now accepted as the *fifth* Founder Society—it seems appropriate to take stock of past achievements that may help us to chart the course of the future. Much of this will be found in three related fields—engineering education, basic science and technology, and the professional development of the engineer.

Training for the Profession. Few if any of the 40 founders of AIChE had formal training in chemical engineering. There were only one or two teachers among them. Yet their organizing chairman, Dr. Charles F. McKenna, in his brilliant address on "The Justification of the American Institute of Chemical Engineers" (see *AIChE Trans.*, Vol. I, pp. 18-20, 1908) said: ". . . You who call yourselves chemical engineers . . . you are to be blamed if you do not demand of educators that in the future the title of chemical engineer be clear, the training adequate and the public encouragement the strongest."

Since then many succeeding committees of industrialists and educators have advanced chemical engineering education in the United States. Under the wise leadership of such men as Arthur D. Little, Alfred H. White, Albert B. Newman and George Granger Brown, the Institute pioneered the accreditation pattern that later was adopted by the entire engineering profession.

Building a Firm Foundation. In his first Presidential address Dr. Samuel P. Sadtler, already a pioneering author on industrial organic chemistry,

TOMORROW

Becomes a Founder Engineering Societies

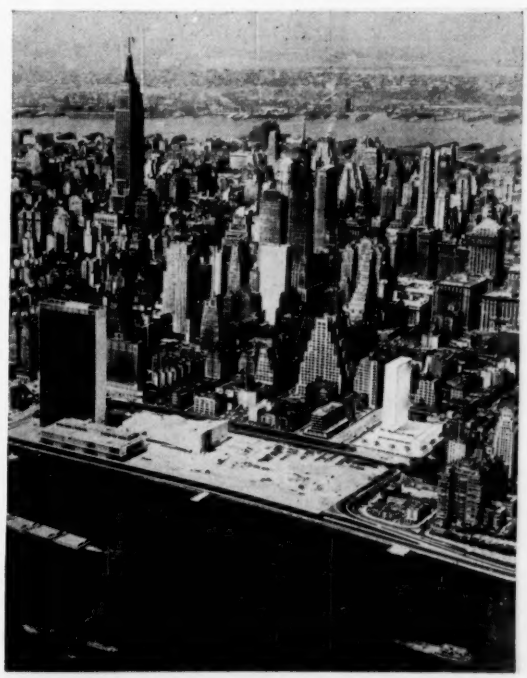
declared that a prime objective of the Institute should be "to publish and distribute such papers as shall add to classified knowledge in chemical engineering and shall thereby increase industrial activity." This, too, was a brave new concept at a time when technical advances were the most cherished of industrial secrets. Over the years the Institute has done just this: First through its *Transactions*, and later through its journals and specialized publications, it has helped to build an enduring literature of theory and practice which otherwise might never have been published.

Professional Development and Recognition. It is most significant that from the very beginning of their planning for a new engineering society the founders stressed the need for developing the professional strength and status of its members. These men were looking for something they could not find in the chemical and scientific societies of their day. Quite openly they turned for guidance to America's oldest engineering society, the American Society of Civil Engineers. It was from ASCE's constitution that the Institute set its own high professional standards for membership. Its first code of ethics came largely from the older society.

Gradually, however, the Institute became a leader rather than a follower in professional matters. When the Engineers' Council for Professional Development was established in 1933 by joint action of the engineering profession of the United States and Canada, AIChE played an important role. Its tested experience in accrediting engineering curriculums and its work with student and junior groups were outstanding contributions. Then came the challenges and chemical engineering achievements of World War II that quickly won public acclaim and recognition.

The great new $10,000,000 United Engineering Center that will soon be built on the United Nations Plaza in New York City will be the home of at least 15 national engineering organizations. And among them there will be *five*, rather than *four*, Founder Societies.

W. H. Byrne, ASME vice-president, and W. L. Barrett, AIEE president, watch demolition for the new United Engineering Center. Site clearing is now completed.



United Engineering Center, to be built at north end of United Nations Plaza, at 47-48th Sts. and the East River, New York, will stand 20 stories high.

A door, long closed to the average engineer, opens here with this introduction to the preliminaries of . . .

Practical Pneumatic Conveyor Design

JOHN FISCHER, Chief Engineer, Materials Handling Div., Sprout, Waldron & Co., Inc., Muncy, Pa.*

Design of today's pneumatic conveying systems still hinges around the empirical approach, with particular emphasis on so-called "seat of the pants" engineering. Judgment and experience play a large part in specification and selection. Most know-how is closely held by the relatively few engineers who specialize in the pneumatics field.

So to date, it has probably been difficult for you, the hard-pressed engineer, to sift the things from available print that you need to know. This article will help to melt any fog and boost you over the hurdles of preliminary design—a cost-saving prerequisite to practical conveyor specification.

* Meet your author on p. 157.

Look at a Little Background

Pneumatic conveying is not a new field of development; it is a logical outgrowth of Sturtevant's work on dust-collecting systems just after the Civil War. However, references in modern engineering literature probably start with the paper published by H. Gasterstadt in 1924.

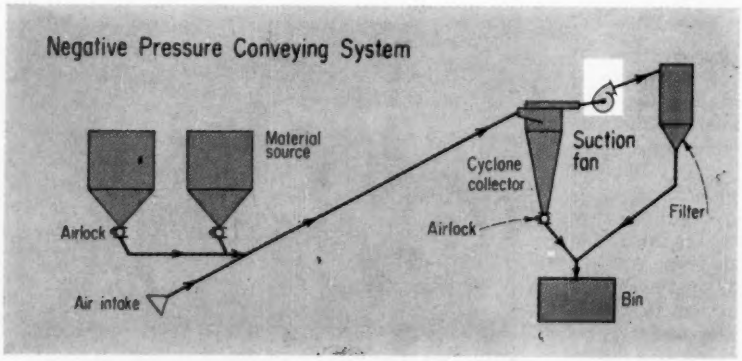
Gasterstadt gives the theoretical laws describing the pressure drops associated with flows of air and air-solids mixtures through pipelines. He worked mainly with granular solids and with grain products, such as wheat. His empirical equations are still substantially correct when applied to material of this character.

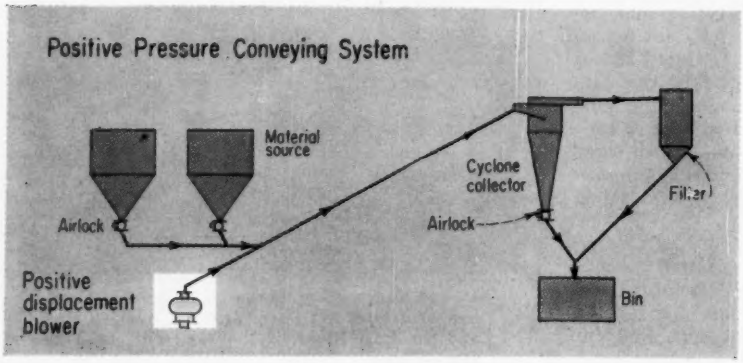
From 1924 on, available data and literature on the subject increased rapidly, especially in the late 1940's. Spurred on by the tremendous growth of fluidized-solids techniques created by the need for aviation gasoline during World War II, oil refiners leaped into all phases of gas-solids contact. Almost immediately, interest in all elements of the country's industry ballooned when management realized that pneumatic systems, a close cousin to fluidization systems, could help close one door to increasing labor costs, while at the same time opening another to greater safety and sanitation. And of course, this new and widespread interest ultimately expressed itself in growing quantities of technical print.

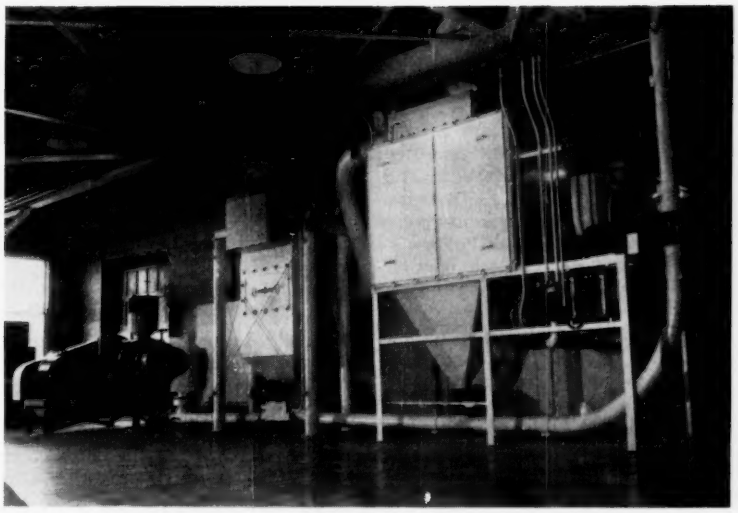
Pneumatic systems have also captured the attention of both designer and architect, who find in its flexibility some release from the rigidity and space requirements of more conventional mechanical systems. Pneumatic conveying lines can go around corners and through walls and floors, where screw conveyors, bucket elevators, and most other types of mechanical units can go only with difficulty.

Flexibility of another kind is provided by self-cleaning characteristics that permit different materials to be conveyed in the same system without appreciable contamination.

Basically, pneumatic conveying systems can be separated into two types: Negative-pressure systems, characterized by relatively low capacity and low pressure losses; and positive-pressure systems, which have higher capacity and higher







pressure losses. Two good rules to follow in design work are:

- When conveying from several points to one point, use a negative-pressure system.
- When conveying from one point to many different points, use a positive system.

Pull the Solids Through

In a negative system, the centrifugal fan, rotary positive-displacement blower or other vacuum-producing unit is situated at the end of the system away from the solids pick-up point. It's necessary, therefore, to put a separating unit, such as a cyclone collector, between pick-up point and exhauster. Solid material discharges from the collector, separated air from the exhauster.

Depending on the collector's separating efficiency, a certain amount of solids entrained in the air stream may carry over into the exhauster. For this reason, designers often select a centrifugal fan as the vacuum producing unit—its large clearances enable it to tolerate the passage of appreciable quantities of entrained solids without serious damage to moving parts. If required, entrained dust can be separated from exhaust air by a filter on the discharge side of the fan.

Since capacity is often limited by the suction pressure which a centrifugal fan can develop, rotary positive-displacement blowers have come into more frequent use with negative systems. However, the extremely precise mechanical construction of these blowers seriously limits their tolerance for dust-laden air. Their use requires that some means be provided to insure a minimum of entrained dust in air exhausted through the blower. Since the efficiency of single cyclone separators generally falls short of tolerance limits, they are combined with a dust-collecting unit.

With these, the exhaust air is filtered through cloth stockings, in a manner similar to the action of continuous automatic dust collectors. As with the automatic collectors, filter design permits isolation of each section for cleaning, while other sections continue the filtering action. Combinations of cyclones and dust filters are sometimes called product recovery units.

Product recovery units are fairly large, in relation to the other components of pneumatic system, because of the large cloth area required for efficient filtration of the air volume being handled. Its large size, in turn, necessitates heavy construction to withstand the system's vacuum.

Push the Solids Through

In a positive pressure system, the source of air flow is located at the head of the line, and air pushes the solids through the duct. It follows that there will be a positive pressure at the point where material enters the line; an airlock of some sort has to be used. Rotary vane units (star feeders) are preferred, but double and triple-gated locks are also employed. Star valves have the advantage of admitting material at a more uniform rate.

Other means of overcoming pressure at the entry point have been devised for the case where process solids are incompatible with a rotating valve. Among these are the use of a choke screw feeder, and also the method of superposing a slightly higher pressure on the materials container, and controlling the rate of feed with a slide gate.

Rotary positive-displacement blowers of the lobed or axial-flow type can produce pressures up to 15 psig. Although there are close tolerances between lobes, no actual contact exists; hence these units operate without internal lubrication. As such, they provide uncontaminated air.

Multistaging can produce higher pressures; however, this introduces temperature problems and additional expense. Therefore, most positive pressure systems operate within the 15-psig. range.

Because relatively low volumes of free air will move large quantities of material through a pressure system, the dust filter can be eliminated if the user is willing to accept small dust losses. Where a filter is required, it can be relatively small.

The table on the next page compares negative and positive systems. The weight ratios of material to air, which range from 1:1 up to 20:1, indicate why some systems are called "dilute" phase, and others "dense" phase. These terms are technically correct, but the term "fluidized," which is more and more frequently used as a synonym for dense-phase conveying, can be misleading. Fluidized

systems should be considered as a third distinct type of pneumatic system.

A fluidized state can be defined as a condition in which all particles are supported on a gas stream, with no material entrained in the stream itself. Material and conveying fluid move as a mass. The attainment and maintenance of this condition is a delicate operation, and one in which particle configuration plays a significant part. Very high ratios of material to air are the rule. As a corollary of the small air volumes used, total energy available in the air to move the supported-solids mass is low. Frictional or other forces that tend to upset the balance result in collapse of the fluidized phase.

Here Are Design Considerations

From the design point of view, there is no fundamental difference between suction and pressure systems, the choice generally being dependent on plant requirements and a consideration of economy. Design is basically a problem in determining the energy requirements. These can be expressed in pressure units, and from them, the size of the blower and required horsepower can be estimated.

Summation of the following five factors, in consistent units, gives the pressure drop across the system:

1. Acceleration energy needed to overcome inertia of the solids, and get them into motion.
2. Energy required to elevate the solids.
3. Energy required to sustain solid materials in the fluid stream, and overcome the material's friction in the conveying duct.
4. Energy losses associated with changes of direction at bends and elbows.
5. Fluid losses in the duct, and at the terminals of the system. These are made up of pressure loss at the system's entrance, friction loss of the pure air stream in the duct work, pressure drop across the collector or separator at the end of system, and losses from any auxiliary units which may be incorporated into the system. Fluid head and kinetic energy terms are generally neglected, unless the system is characterized by unusually large vertical lifts or fluid velocities.

Four of these design components are based on an important variable —velocity. Many references in the literature describe how to determine conveying velocity of solid materials. Theoretical velocity for conveying fine particles can be calculated with Stokes' law; Newton's Law holds for large particles. Other investigators have suggested empirical formulas of more or less complexity.

There's a small fly in the ointment, however. All of these methods give only the critical or balancing velocities. So the designer usually assigns an additional empirical value to insure the sustained movement of the particles. Here, judgment comes into play; however, Alden's "Handbook of Industrial Exhaust Systems" offers a list of adequate conveying velocities in Table 19. This table suggests velocity ranges from 3,000 to 7,000 ft./min., depending on the bulk density of the material, and probably in part on the particle size and configuration.

For the purposes of this article, and for nearly all conveying systems involving material with bulk densities ranging from 25 to 60 lb./cu.ft., a velocity of 5,000 ft./min. will be found satisfactory. (This may seem to be an excessively high speed; however, the author has noted that particles in an air stream rarely attain more than 80% of the theoretical air velocity—and in short systems, even less.)

Now let's look at the design factors in greater detail:

Acceleration—Material at rest has energy of position, which has to be converted to energy of motion. Substituting our assumed velocity of 5,000 ft./min. into the formula $E_1 = Mv^2/2g$, we get an acceleration energy of 1,800 ft.-lb./min. per 1,000 lb./hr. of solids conveyed.

Lifting Energy—Energy required to lift a given amount of material a given distance can be expressed as $E_2 = M \times d$.

Horizontal Requirements—This is probably the most controversial element of all. Unless the solids are of a type that can be held in suspension, that is, fairly light in weight and of particular particle geometry, they move along the bottom of the pipe in a fairly steady stream.

For our purposes we will assume, then, that the energy required to move a material is equal to: $E_3 = M \times d \times f$, where f is actually a "finagle" factor. In the equation above, f is given as the coefficient of friction (calculated as the tangent of the angle of slide) between the material being conveyed and the material from which the duct is made. For most practical purposes, this factor provides satisfactory and duplicable results.

Bends and Elbows—It is desirable to make the transition from one direction to another a gradual one. Some granular materials, and even some finely powdered materials, have abrasive properties and can cause erosion at a bend. Also, sharp bends result in a stoppage or pile-up requiring re-acceleration.

For these reasons, elbows and bends in pneumatic conveying lines should have fairly long center-line radii, ranging from 36 to 72 in. It's possible to convey material around bends with shorter radii

Duct Size, Flow Rate, Friction Loss and Capacity Range

Duct Diameter	Flow, Scfm. at 5,000 Fpm.	Friction Loss, In. H_2O/100 Ft.	Usual Capacity, Thousand, Lb./Hr. Negative	Positive
4-in.	440	11.0	2— 6	12—40
5-in.	680	8.0	3—10	15—60
6-in.	980	6.3	4—15	20—80
8-in.	1,800	4.5	15—30	30—160

Nomenclature

d	Distance, ft.
E_1	Energy of acceleration, ft.-lb./min.
E_2	Vertical-lift energy, ft.-lb./min.
E_3	Horizontal-run energy, ft.-lb./min.
E_4	Energy loss at elbows, ft.-lb./min.
f	Coefficient of friction.
g	Acceleration due to gravity, ft./sec.^{2}
M	Solids moved, lb./min.
R	Radius, ft.
v	Velocity, ft./sec.

than this, but only with considerable additional energy.

Assuming a radius of 48 in. for a 90-deg. elbow, the weight of solids moving around the bend is multiplied by the centrifugal force imparted to it. Using the formula $E_4 = (Mv^2/gR) \times d \times f$, we obtain a value of $5{,}700f$ ft.-lb./min. per 1,000 lb./hr. of material handled.

Air Losses—Although all energy expenditures above have been stated in units of ft.-lb./min., air losses are usually expressed as in. H_2O. It is convenient for our purposes to leave them in these units. Air losses break down to pipe losses, entrance losses, cyclone separator resistance, and filter resistance. If the conveying line includes heat exchangers or intake filters, their resistances should be added.

Air resistance in the duct is a function of velocity and volume. The chart (see next page), reproduced from Marks, "Mechanical Engineers Handbook," gives pressure losses for 100-ft. lengths of duct as a function of flow rate and line diameter. Alden's Handbook presents a similar chart on pp. 104-5. Care must be taken to include equivalent footage involved for each elbow and bend; e.g. for a 48-in. radius, 90-deg. elbow, add 6.25 ft. of duct (from $2\pi R/4$).

Entrance losses are generally of small magnitude in relation to the rest of the system, and most always can be ignored. In most negative pressure systems, they are on the order of 2-3 in. H_2O.

Cyclone losses vary, and can usually be assumed to be twice the velocity pressure ($2\frac{1}{2}$ to 4 in.). Filter resistances are given, generally, by the manufacturer. Most commercial cloth-type collecting units are designed for an average resistance of 4 in. H_2O.

Math Doesn't Tell Whole Story

The two typical examples show a reasonable and workable approach to the problems in preliminary design of pneumatic conveyors. There is much more to the story than the final numbers show, however. There are so many little-known or dimly suspected variables and factors affecting the performance of pneumatic systems that we are pleasantly surprised when this performance corresponds exactly to our calculations.

Example 1—Typical System

Problem—Assume that we want to convey 3,000 lb./hr. of powdered resin from any one of three storage bins to a mixer. Conveying distance is 150 ft. horizontally and 25 ft. vertically; the conveying line includes six 90-deg. elbows. Measured angle of slide is 35°; assume $f = 0.7$ (Tangent 35° = 0.7). Calculate required power input.

Solution—We'll use a negative system.

Material Losses:

1. $E_1 = 1{,}800 \times 3$ = 5,400
2. $E_2 = (3{,}000/60) \times 25$ = 1,250
3. $E_3 = (3{,}000/60) \times 150 \times 0.7$ = 5,250
4. $E_4 = 5{,}700 \times 0.7 \times 6 \times 3$ = 71,820

Total material losses = 83,720

Assume that we'll use a 6-in. line. For this, the table shows a 980-cfm. flow rate. Therefore, energy losses attributable to solids flow can be expressed as:

$$83{,}720/(980 \times 5.2) = 16.5 \text{ in. } H_2O$$

where 5.2 is a factor that converts lb./ft.^{3} to in. H_2O.

Air Losses:

Also from the table, or chart, we see that air losses for 5,000 ft./min. in a 6-in.-dia. duct are 6.3 in. H_2O per 100 ft. So:

1. Duct losses
   150+25+(6×6.25) = 212.25 ft. pipe
   (where 6.25 ft. is the length of a 90° elbow at a 48-in. radius)
   = (212.25/100)×6.3 = 13.4 in. H_2O
2. Cyclone losses = 3.0
3. Filter resistance = 3.0

Total air losses = 19.4 in. H_2O

Material losses plus air losses = 16.5 + 19.4 = 35.9 in. H_2O. Converting this to horsepower:

Hp. = (cfm. × pressure losses)/ (6,350 × efficiency)

Efficiencies of centrifugal fans range from 40 to 66%. We'll use 50%.

= (980 × 35.9) / (6,350 × 0.5) = 11.1 hp.

A 15-hp. motor, operating a centrifugal fan delivering 980 cfm. in a 6-in. line, will give an adequate margin of safety.

Example 2—An Exception

Problem—Make preliminary design calculations for a conveyor to move starch from a dryer to storage at the rate of 20,000 lb./hr. Horizontal conveying distance is 400 ft. and vertical lift is 50 ft. There will be four 90° elbows, two 45° elbows, and one 30° bend (a total of 5.33, 90° bends) in the conveying line. Angle of slide is 40°; tan 40° = 0.835.

If we convey from one point to one point, theoretically, a negative system should be most satisfactory. However, the quantity and distances involved here are such that pressure requirements exceed the capabilities of a centrifugal fan, and add unnecessary expense. Hence, a straight positive pressure system is indicated.

Solution—We'll use a positive system.

Material Losses:

1. $E_1 = 1{,}800 \times 20$ = 36,000
2. $E_2 = \frac{20{,}000}{60} \times 50$ = 16,700
3. $E_3 = \frac{20{,}000}{60} \times 400 \times 0.835$ = 111,000
4. $E_4 = 5{,}700 \times 0.835 \times 20 \times 5.33$ = 507,400

Total material losses = 671,100

For a 5-in. duct, the table shows a flow rate of 680 cfm.

$$671{,}100/(680 \times 5.2) = 190 \text{ in. } H_2O$$

Air Losses:

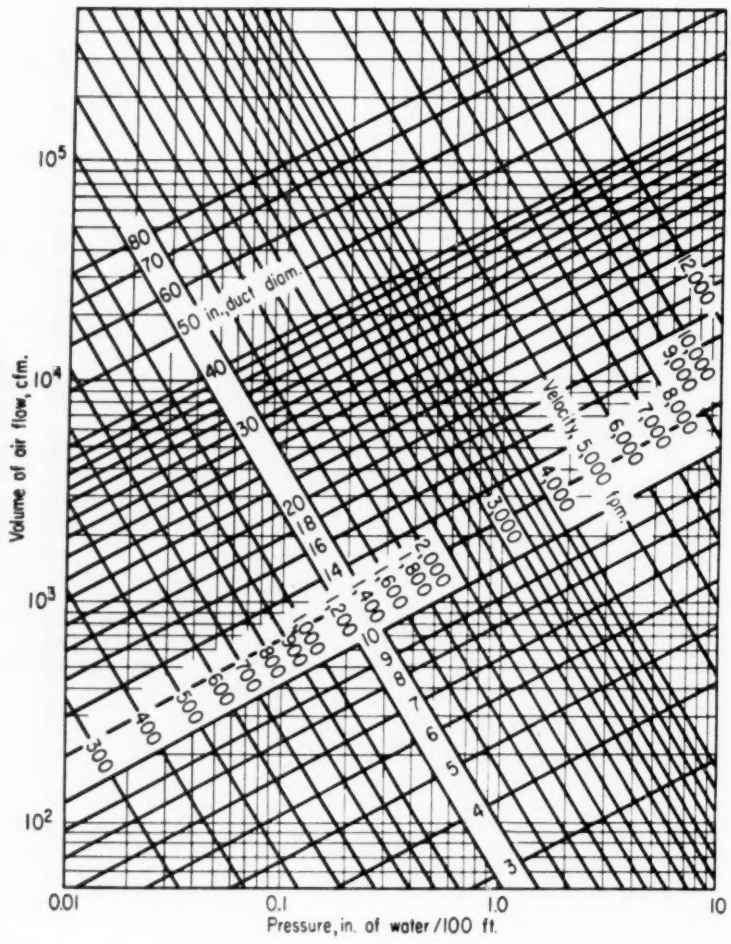
From the table, losses are 8.0 in. H_2O per 100 ft. So:

1. Duct losses
   400 + 50 + (5.33 × 6.25) = 483.3 ft. pipe
   = (483.3/100) × 8.0 = 38.6 in. H_2O
2. Cyclone losses = 3.0
3. Filter resistance = 3.0

Total air losses = 44.6 in. H_2O

Material losses plus air losses = 190 + 44.6 = 234.6 in. H_2O, or 234.6/27.78 = 8.5 psig.

A rotary positive-displacement blower, moving 680 cfm. against 8.5 psig., will suffice.



Accordingly, we temper theory with judgment and conservatism. The spread of horsepower ratings available in electric motors gives us ample opportunity to utilize this tempering facility; for example, if calculations indicate that 12 hp. is required, the use of a 15-hp. motor provides a 25% safety factor. If we get an answer of 10.5 hp., sufficient conservatism exists in the formulas to enable us to specify a 10-hp. motor without hesitation.

There are other more difficult problems of choice, which can assume considerable proportions, and which justify the existence of the specialist for final design. For example, characteristics of materials can be deceiving. Free-flowing soda ash, apparently an ideal material to convey, is sluggish, and requires extra power. Finely ground pigments such as Fe_2O_3 build up rapidly in elbows and cyclones, eventually stopping the flow. A slight change in the percentage of water of hydration will mean the difference between a highly abrasive alumina and one that will cause no wear at all.

Then again, things other than purely economic considerations often determine the choice of a system. In some crushing and grinding operations, a negative conveying system will also serve the secondary objective of drawing air through the unit for cooling and cleaning. Chances are that a negative system will win out for such an application, even though a positive pressure system would cost less money. When inert gases are used for conveying, and the presence of oxygen is undesirable, positive pressures are preferable. On the other hand, when material being conveyed is toxic or noxious, the need to avoid outward leakage is frequently a dominating factor in the choice of a negative conveying unit.

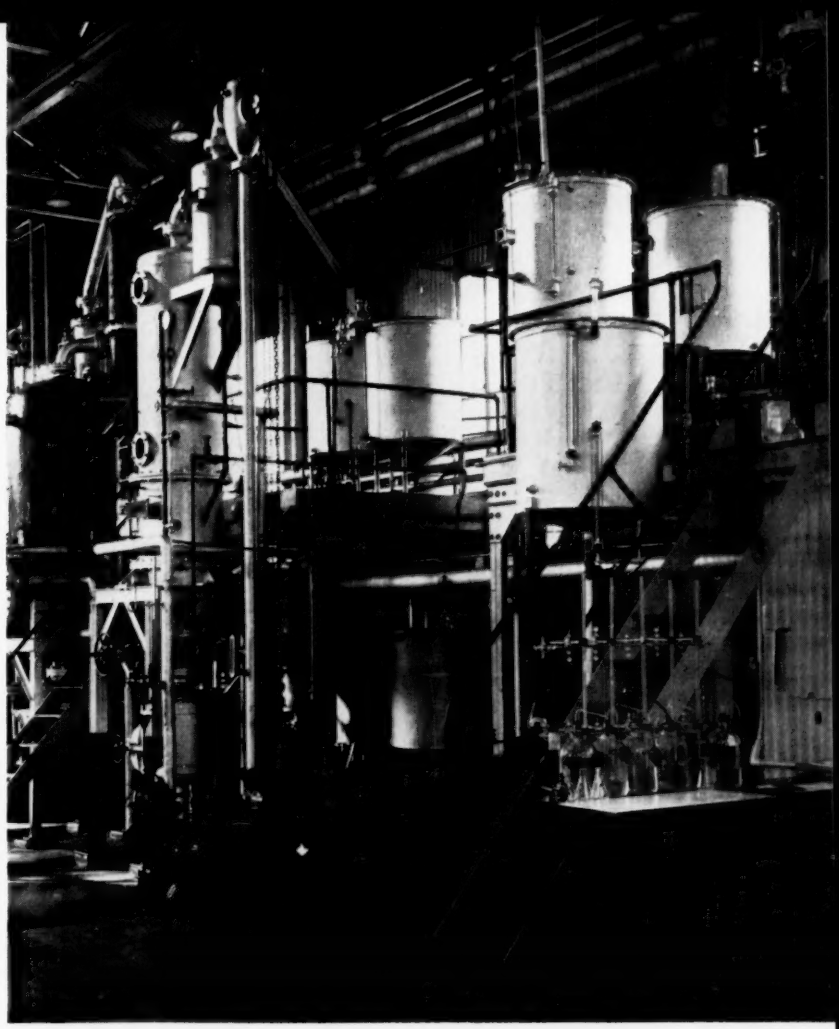
The pneumatic-conveying specialist can provide still another service in the problem of choice. We haven't said much about disadvantages of pneumatics, but there are a few. Many instances arise where air handling is not economical or feasible, and where other types of conveying are more practical. Screw conveyors, vertical screw lifts, bucket elevators and belts usually require less power to operate per ton of solids handled. Some mechanical units can move fragile materials more gently than air can. The specialist frequently combines pneumatic and mechanical units, retaining the function desired, while still effecting considerable savings.

Remember to Consider These

In contemplating final design and installation of a conveyor, any project engineer should consider, or furnish the supplier of the system, with the following information:

1. Distance traversed. This involves the lift, horizontal distance, and number of bends.
2. Solids characteristics. Size analysis, bulk density, and degree of hygroscopicity of the material to be conveyed.
3. Feed considerations. Will the rate of introduction to the conveying line be uniform, or should the supplier provide for uniform feed rate?
4. Automation. To what degree is it desired? Should switches and diverter valves be manual or automatic?
5. Electrical. What are the current characteristics in the plant?

In closing, it might be well to point out that the diversity of special uses to which pneumatic conveying systems can be put is unlimited. For example, they can be used for drying, heating or cooling while conveying. They can be designed to maintain the moisture content of the material being conveyed. They can even be used, to a limited degree, for size separation and size reduction. These uses, however, make another story.



How the development engineer can use his knowledge of the unit operations to decide which need piloting and which can be bypassed because sufficiently good correlations are already available to him.

Unit Operations in the Pilot Plant

E. L. CLARK, Consulting Chemical Engineer, Pittsburgh, Pa.*

CHEMICAL ENGINEERS have a set of tools in the unit-operations concept for handling many industrial and research problems. Actually this concept has been the primary basis of chemical engineering as a profession. The thesis of the unit operations approach is that there are certain component steps or operations used in all industrial processes; these steps can be individually studied; once the basic principles of the individual operations are known, these principles can be applied to any future new process. The first formal statement of this point of view has been credited to Arthur D. Little in his report to the Corporation of the Massachusetts Institute of Technology in 1915.

It is obvious that a thorough knowledge of these various unit operations is mandatory for the technical man engaged in pilot plant experimentation. Most chemical pilot plants involve the transfer of heat between fluids, or fluids and solids, at different temperatures and most require that materials be transported to, within and from various pieces of equipment. In many processes, material transport between phases is a critical factor.

In all these we are concerned with those basic topics taught to the embryo chemical engineer as Fluid Flow, Heat Transfer, Materials Handling and Mass Transfer. Most pilot plant processes use common separation techniques for feed, product and recycle streams such as Distillation, Filtration, Screening, Classification and other

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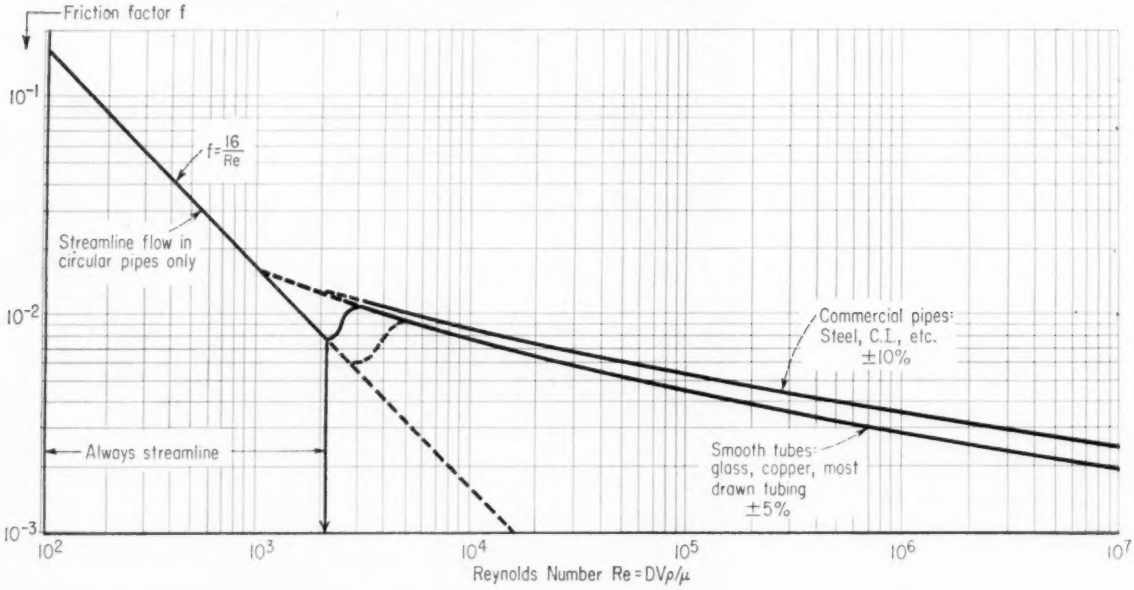
April 21: Introduction
This Issue: Unit Operations
Coming: Equipment and Safety Size Extrapolation, Scaleup.

*To meet your author see *Chem. Eng.*, Apr. 21, 1958, p. 186.

Familiar friction factor plot is useful if limitations are recognized.



Size Separations, Absorption and Crystallization; not to mention the newer techniques such as Ion Exchange, Gaseous Diffusion and Mixed-Phase Extraction.

Thus, we see the need of using the knowledge of these unit operations in the design of pilot plant facilities, just as one would use the same knowledge for the design of the industrial counterpart.

However, a much more important use of this knowledge of unit operations is to limit the scope of the pilot plant program so as to decrease its cost and duration. As an obvious example, we normally do not need too much pilot-plant testing in the design of fluid handling systems. Our knowledge of the energy and equipment requirements for such systems is sufficiently developed to eliminate most technical or economic risks, so we can often calculate and design such systems without any experimental work on a pilot plant scale. For new fluids, however, we must determine certain physical properties to permit the use of available correlations. And, occasionally, we encounter a fluid which does not fit into our correlations and then some experimental effort is required. This problem was encountered in the long-distance transport of coal-water and gilsonite-water slurries. In these cases considerable experimental work was necessary. The engineer, in planning the pilot plant program, must make the important decisions as to when experimental work is needed and when the knowledge available for a particular unit operation is adequate to permit direct calculation of industrial plant design.

A fine example of such an approach was presented by W. G. Daroux[1] in his account of the development of a process for the production of acetic anhydride from acetone. He showed the entire sequence of laboratory results, pilot plant testing, and industrial plant design for this process. The laboratory found that the uncatalyzed thermal decomposition of acetone produced methane and ketene. The ketene could then be reacted with acetic acid to form acetic anhydride. However, at the temperature of 1,200-1,500 F. required for the decomposition, both ketene and acetone also engage to a small extent in undesirable side reactions, forming C_2H_4, CO, H_2 and C.

The main reaction of acetone to ketene was endothermic, with an energy requirement of 29,000 Btu./lb. mole. The acetic acid absorption of ketene to form acetic anhydride was exothermic and gave off 42,000 Btu./lb. mole. The economics of the process was satisfactory, so it was decided to evaluate the reactions on a pilot plant scale.

The scope of the pilot plant investigation was carefully limited to simplify the experimental unit. The primary problem was the design of a suitable furnace in which the decomposition reaction could take place. To simplify the scaleup problem, the pilot plant furnace used the tube size selected for the industrial furnace by preliminary design calculations. However, the pilot plant consisted of only one of the several parallel tube systems planned for the industrial scale.

No feed preparation system was installed as the crude feed could be redistilled in the laboratory, and the design of the industrial units could be calculated using laboratory data. Nor was the product separated since the absorption and fractionation systems could be designed using laboratory data on the components. Samples of product were analyzed to determine furnace performance.

The cost of the pilot plant was, therefore, only a fraction of what a complete prototype would have cost. Furthermore, the time needed for getting a complete pilot plant into operation on a continuous basis was eliminated. Pilot plant data on the conversions were utilized for the design of the commercial plant, plus a calculated design of the fractionation, absorption

and heat transfer portions. The plant operated satisfactorily.

In this instance a dependable knowledge of the unit operations of absorption, distillation and heat transfer permitted a major reduction in scope of the pilot plant unit, resulting in a major reduction in both equipment and operating costs and a more rapid achievement of necessary information. As is normal, the pilot plant operation was not without difficulties, but these were solved by the combined efforts of the pilot plant and laboratory personnel.*

The reverse of the previous example is possibly even more critical. The engineer must not make careless assumptions concerning the scope of existing correlations or data available for any unit operation. The error of not including doubtful items in the pilot plant experimental program can produce serious plant delays, with excessive startup problems and costly losses of production. In a nutshell, the correct decision must be made; a thorough knowledge of the fundamentals of any unit operation involved is the only reasonable basis for the decision.

* An interesting incidental point is brought out in this paper. The laboratory reactions were carried out in silica and copper tubes. The pilot plant furnace tubes were of stainless steel. These tubes catalyzed the dehydrogenation of acetone to produce carbon and the furnace tubes became plugged with coke. This problem was returned to the laboratory and it was found that the catalytic action of the stainless steel tubes could be poisoned with a minute addition of carbon disulfide. This type of cooperation between laboratory and pilot-plant is an essential factor to the success of the experimental program.

When this point was brought out at a seminar conducted by the author two philosophical arguments were raised. First, the laboratory should have tested stainless steel tubes before the pilot plant was constructed. Second, it was fortunate that the laboratory did not test stainless steel tubes; the fact that the pilot plant was already built forced the laboratory to come up with a solution; a laboratory test on stainless steel tubes with the resultant coking difficulties might have caused abandonment of the process. I leave it to the reader to resolve this point.

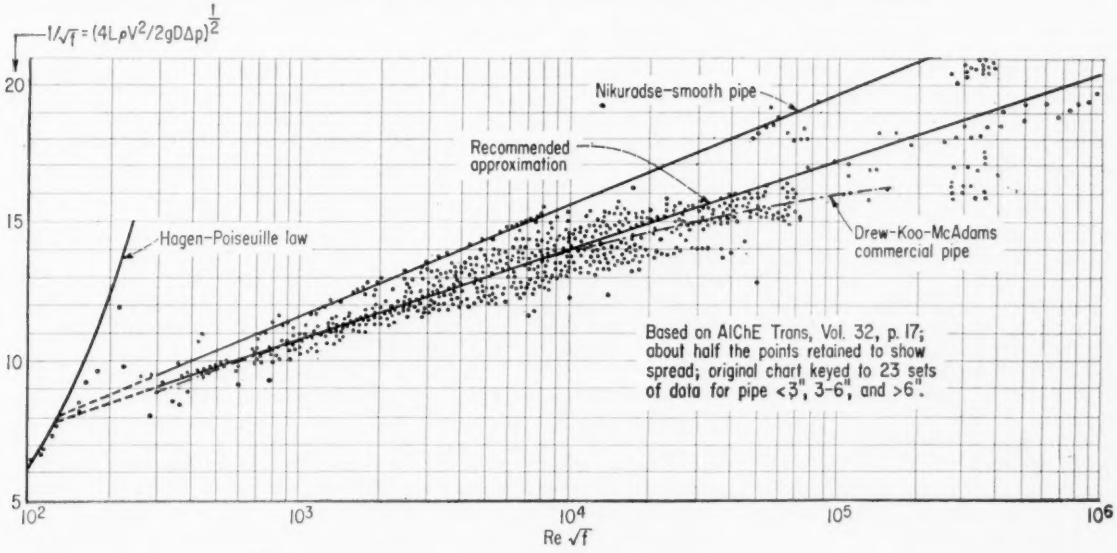
Know Your Unit Operations

The most important information for the engineer who must make a decision on the scope of a pilot plant program is an understanding of the scope and potential accuracy of existing data or correlations. We are all too prone to accept the printed word as equivalent to truth. We are all apt to accept shortened, simple formulas in preference to more complex relationships without evaluating the assumptions and limitations included in the simplification. An article by L. M. Polentz[2] brings out this point for flow systems. However, even the so-called "basic relationships" are to a great extent empirical correlations of experimental data and have definite limitations.

Consider, for example, what is probably the best-known and most widely used correlation for fluid flow, the friction-factor vs. Reynolds number relationship for conduits of circular cross-section. The curves shown on the previous page are well known to every chemical engineer, and appear in various texts[3] and handbooks.[4] (There are variations of these curves in some texts where an f value equivalent to four times the f value shown here is used. Another variation is the addition of curves for pipes of varying roughness[5]). Most of these curves are based on the work of Drew[6] and his co-workers who correlated the experimental results of many investigators. Referring to the original experimental results, we find that most of these results were for water, steam and air with only a minor amount of data on other fluids such as brine and other gases. This means that there is no real assurance that including fluids of varying physical properties may not alter the position of these curves or change their accuracy.

The additional curve for "Commercial Pipes" was questioned in a paper by Miller[7] and with some justification since the disturbance caused by joining pipe lengths may introduce serious differences in resistance to flow. Drew and Genereaux[8] presented a rebuttal to this contention and added data on hydrocarbon fluids. Their rebuttal seemed to bear out Miller's

Variations in "Commercial Pipe" introduce more error than many realize.



contention at high Reynolds numbers. A simplified version of their chart, presented on p. 121, shows the possible variation due to differences in so-called "Commercial Pipes." We find that the variation is considerably greater than the ±10% claimed for this correlation.

It is not our purpose to suggest that this correlation should be discarded. On the contrary, it should be used, but with a realization of its limitations. In addition one must understand the approximate accuracy allowable for design correlations. If design engineers are quite willing and accustomed to using relationships which are accurate to only ±20% or ±30%, then the pilot plant engineer can also accept the same standards for many unit operations.

There are, of course, many exceptions where greater accuracy is necessary owing to the severe economic impact of minor variations. Without too much concern over cost, we can select a slightly larger pipe size than actually necessary to connect two process units and thus compensate for possible lack of accuracy in the design correlations. However, I remember vividly one case where an excessive pressure drop through a catalytic reactor, over and above the built-in safety factor, required major equipment modification and expensive plant down-time.

A unit operation closely related to fluid flow is that of forced, convective heat transfer within or outside tubes. It is common practice to use various correlations in designing heat exchangers. McAdams[8] mentions several equations which can be used to evaluate film coefficients. These are in the form of products of the powers of three dimensionless groups; the Reynolds number, the Prandtl number and the Nusselt number. The most familiar of these is the well-known Dittus-Boelter equation first presented in 1930.[9]

Another similar equation differs in that the viscosity of the fluid is also determined at the wall temperature of the tube, as well as in the powers assigned to the dimensionless groups. In the Dittus-Boelter equation, however, the fluid properties are those at the bulk temperature of the fluid. This equation is the Sieder-Tate relationship presented in 1936.[10]

McAdams states that the latter type of equation is probably preferable. He has correlated data on water and petroleum fractions and reports deviations of +43 and −33% for this relationship. In spite of this wide deviation we do not hesitate to design heat exchangers. However, we usually consider this possibility of wide deviation by increasing the surface 50 to 100% over the calculated value for most commercial heat exchangers.

This second example indicates again the normally expected accuracy for a rather well-known correlation for a well-explored unit operation. Efforts are constantly being made by industrial laboratories to increase the accuracy of heat transfer calculations and those for other unit operations. Obviously, if we could reduce the overdesign requirements, considerable plant investment could be avoided.

From the evaluation of probably the two best understood and most widely used unit operations, we can see that our requirements are not too rigorous. Existing correlations for unit operations may be used for plant design, provided we can depend on an accuracy of probably ±40-50%. In many cases the handling of materials in a new process, both in the laboratory and in a limited-scope pilot plant, will provide enough information to decide whether individual unit operations require additional investigation. Very often, a few additional measurements in the course of pilot plant study of the reactions will show whether more detailed investigation is needed.

In any event, an informed engineer should be familiar with the margins of error and scope of the correlations being used for design of chemical plant systems. As pointed out in this brief discussion, even so-called "basic relationships" are merely empirical formulas relating only to the experimental data available to the correlator. Frequently the scope and variety of the data limit also the scope and variety of the application.

It would be very convenient if we could list all the unit operations and state with assurance that for these, pilot plant effort is not needed while, for those, pilot plant experimentation is mandatory. The situation is not that simple. We have already examined some of the potential deviations in "tried and true" methods. Uncertainty of this sort follows us in each unit operation. It would be very instructive to consider each unit operation in detail, but such procedure would be considerably beyond the scope of a single article on applications of unit operations.

In what follows the unit operations have been arbitrarily divided into several groups which overlap somewhat. In addition, we shall disregard the classical categories developed for purposes of instruction. The groups are primarily based on the type of experimental problems involved, and we shall try to establish some guide lines for determining when pilot plant investigation seems advisable.

Momentum-Exchange Operations

This class of unit operations is quite large. It includes the transfer of fluids, which is the most obvious case of a unit operation based on inducing or exchanging momentum, and also many other unit operations. As examples we may include: the transfer of heat by forced convection; mixing of fluid and fluid-solid systems; and the sedimentation of solids. In addition, the problem of degree of turbulence or momentum is of great importance in many unit operations based on reaching a state of equilibrium.

There are two general possibilities for complication in operations depending on momentum exchange or turbulence. The first is the type of fluid being handled. The second is the complexity of the system and its geometry. Most of the existing correlations are based on fluids such as air, water and steam and are valid for most similar fluids. Since most of the experimental work has been done on straight pipes of circular cross-section, our correlations for this type of flow system are most accurate. For such fluids and simple systems no pilot-plant experimentation appears needed.

When the properties of the fluid being handled depart greatly from those of the fluids on which our correlations are based, the experimenter should be more cautious. The literature contains considerable data on non-Newtonian liquids where shear rates or viscosity vary

with applied pressure. There is considerable information on liquid metals, slurries and other unusual materials. Many times the correlations can fit the material being used. However, in other cases, wide variations may be encountered. Very often a few pressure-drop measurements on a length of pipe in an existing pilot plant or bench-scale unit can eliminate a great deal of uncertainty.

A similar problem exists as the complexity of the system increases. It has been previously mentioned that the correlation of friction factor vs. Reynolds number is probably accurate to ±10% for ordinary straight pipe. However, when modified Reynolds numbers are used to correlate pressure drops through packed columns or catalyst beds the accuracy of such correlations drops to ±25% or ±35%. In such cases, considerable care should be exercised in designing equipment and some additional measurements on a pilot plant scale may be profitable.

One special case for which it is very difficult to define the flow system accurately is in the mechanical mixing of liquids, or solids and liquids. In spite of much work by very capable investigators, it is still a problem to define the turbulence and power input, plus the extent of mixing, even for geometrically similar systems of different size. Therefore, it is an excellent idea to perform experimental work on a larger scale than that usually employed in the laboratory for those processes dependent on the extent of mixing.

It is possible to summarize the processes dependent on turbulence by stating that: for normal Newtonian fluids in most systems, no special pilot plant experimentation is required. This includes most operations involving fluid transfer, heat transfer and sedimentation. For special systems of great complexity, or unusual fluids, we must take care in determining whether pilot plant work is required. The problem of mixing is considered an especially complex system.

Stage-Calculation Operations

The simplest example of a system amenable to stage-wise calculation is a one-stage, two-component distillation in which liquid and vapor are at equilibrium at some temperature and pressure. The vapor is constantly removed, containing more of the volatile component than the liquid. The latter is also continuously withdrawn and contains more of the non-volatile component. Knowing the equilibrium relationships between liquid and vapor compositions at various pressures and temperatures, we can predict the results for one or more stages. Other types of system amenable to similar treatment are those for extraction, absorption, adsorption and some types of chemical reactions. Once the data on the equilibrium relationships are determined in the laboratory, we can calculate the number of equilibrium stages required to attain a desired result. Through a material and heat balance we can also size the industrial plant equipment needed for the process flow diagram. No pilot plant work is required. The example of the development of an acetic anhydride process already described indicates how a pilot plant was simplified by such an approach.

Again, unusual materials must be viewed with suspicion. In a fractionation system heat must be transferred, liquids must be pumped and metered. The criterions for unusual liquids which we discussed under processes involving momentum transfer must be considered also in these stage processes. The attainment of proper equilibrium depends on achieving intimate contact between fluids. Hence, proper design of equipment for special combinations of fluids may require experimental assistance. In case of corrosive and thermally unstable fluids we may need to investigate to insure proper selection of materials of construction and heat transfer systems. These are normal precautions which must be observed.

Obtaining a reasonable approach to equilibrium in an actual stage is a problem always faced by design engineers. Various commercial designs of contacting devices are on the market and have been used in many systems. However, the evaluation of factors affecting the design of packing or plates for fractionation, absorption or extraction columns is still under study. In fact, the American Institute of Chemical Engineers selected this problem as one of importance for the allocation of research funds. In the meantime, design engineers are able to design successful industrial units from laboratory data, albeit with some factor-of-safety capacity to compensate for areas of ignorance.

As we mentioned, these arbitrary divisions of unit operations into groups result in a great deal of overlapping. For example, although a leaching system can be designed as a series of equilibrium stages, it involves problems with other unit operations. The solid material being leached must be intimately mixed with the liquid to obtain an equilibrium distribution of the material being extracted between the solid and the liquid. Here, the size and scope of the pilot plant may be determined by our investigation of proper mixing equipment. Similarly, designing a reboiler for a thermally labile material may require experimentation with a fractionation system on a somewhat larger scale than required for the fractionation itself.

To summarize, those unit operations which we have listed as amenable to stage calculation do not normally require extensive pilot plant testing.

Operations Using Simple Models

A convenient example of operations amenable to simple models is the screening of a solid for separation of a specific size fraction. In our laboratory test we take a small unit area of the screen size we wish to use and determine the quantities involved. Sufficient data are available to determine the area of industrial screening device required. Here we have used the simplest type of experimental model—a unit section of the actual device. For designing the industrial unit, we merely increase the number of sections or the area to accommodate the throughput required by our flow diagram. No pilot-plant experimentation is needed.

Other processes of similar character include settling of solids and filtration. In all such cases a unit area of a settling basin or a filter leaf is used to determine the area required for the full-scale equipment. Occasionally a chemical reaction is amenable to such treatment. For example, the Downes converter for phthalic anhydride

production consisted of a bundle of catalyst tubes in a heat transfer fluid. The single tube of a size which could be investigated on a laboratory scale was a unit section of the industrial reactor.

Again we have a good possibility of completely eliminating the need for pilot plant experimentation. Naturally, there are problems and exceptions. Several of the examples involve solids and solid particles. Handling these requires special precautions which will be discussed in the next section. Here experimental techniques are critical since wall effects and poor distribution may give spurious results. Still, many industrial units are designed on the basis of small-scale tests without any pilot plant work.

The use of unit elements as models will be discussed in more detail in a later report on scaleup, extrapolation and data application.

Operations Involving Solids

The problems that arise in handling solid particles are worthy of special mention. Most of these problems stem from the difficulty of precisely defining and producing a particle. For example, in operating a fluidized bed, it is much easier to obtain uniform fluidization and stable conditions with quartz sand than with coal particles. Leva *et al.*[11] have reported on the differences between round and sharp sands, Fischer-Tropsch catalyst and anthracite coal particles in experimental studies on fluidization. To complicate matters, the type of particle is dependent on the method of preparation. Particles produced in the laboratory are often quite different from those which might be obtained on a plant scale.

We often encounter this situation in preparing mineral ores for treatment by crushing or grinding. The treatment is often seriously affected by the method of size reduction. Impact breaking of the ore may cause size reduction by cleavage along boundaries between heterogeneous materials. Then the minerals within the ore became more readily available to extraction or physical separation. Size reduction by abrasion may result in an excess of fines from which recovery of mineral values may be difficult.

Effect of recycling oversize materials in closed-circuit crushing or grinding is not always capable of calculation on account of variations in hardness among the various components. While we may use various laboratory techniques and correlations to determine equipment sizes and power requirements, we cannot always be sure of the effect of variations in particle characteristics.

An idea of the size of equipment that may sometimes be needed to obtain definitive information can be gained from the announced installation of a $255,000 "experimental rod mill" by the Kennecott Copper Corp. This would determine whether its operation would be more economical than the equipment now being used.[12] It can be concluded that size reduction may require pilot plant testing.

The difficulties of particle definition affect such unit operations as sedimentation and filtration. Although we can size industrial equipment for these operations on the basis of laboratory tests, we must be certain that the particles are genuinely representative. In one case there was a very great difference in settling rates for a leach residue as determined by two laboratories. One laboratory took an ore sample, leached it and then used the slurry of spent ore to determine the settling rate. A sample of the same slurry was shipped to the second laboratory for examination. It seems that time, or possibly movement of the slurry in the shipping containers, produced a different state of particle aggregation, with a different settling rate. When the second laboratory went through the entire procedure of leaching and then determining the settling rate, similar results to those of the first laboratory were obtained. This illustrates the great possibilities for error from faulty experimental procedure in processes which handle solids.

We encounter even greater problems when we attempt to produce a particle of special characteristics by precipitation, either through chemical reaction or by evaporation and crystallization. Very often minor variations in process conditions, small additions of impurities, or local changes in concentration or turbulence may radically alter the type of particle produced.

These minor variations may not appear on a small scale where careful control is exercised by technical personnel. However, on a larger scale there are greater possibilities for local differences and minor impurities and contamination. An example of a process in which the method of precipitation is very important is the production of titanium pigments. There is an extensive patent art on the techniques of precipitating titanium oxide from the leach liquor. Such processes must be tested on a reasonably large scale to insure their industrial operability and product quality.

The handling of solid particles does require some special consideration. As we improve our ability to characterize particles according to their surface, porosity and shape, our understanding will increase. For the time being, the engineer must take warning.

To conclude, the great diversity of problems in pilot plant experimentation means that our only certainty will be uncertainty. Although we can anticipate the need for pilot plant work on some operations and expect to bypass it on others, we must learn to treat the unusual material or combination of materials with suspicion, even for the best-known and understood unit operations.

Not much has been said here about the use of unit operations in designing pilot plants themselves. In the following article on pilot-plant equipment, we shall consider this subject as various types of equipment are discussed.

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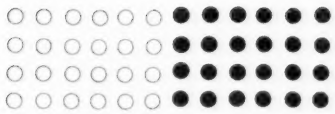

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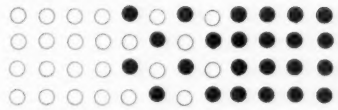
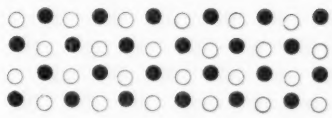


Diffusion coefficient measures rate of molecular intermingling.



Predict Diffusion Coefficient, D

Comparatively few diffusivity data have been published. That's why this two-part article on reliable prediction and extrapolation methods will prove quite valuable. This issue: gases. Coming soon: liquids.

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Molecular diffusion is a process, extremely widespread in nature, whereby molecules of one substance gradually interpenetrate another substance. Sherwood[1] has defined it as "the spontaneous intermingling of miscible fluids placed in mutual contact, accomplished without the aid of mechanical mixing."

We are interested here in what is variously called the coefficient of diffusion, diffusion coefficient or molecular diffusivity, usually denoted by the symbol D (and not to be confused with thermal diffusivity, which is $k/\rho\ C_p$).

Diffusivity is defined as the ratio between the amount of material transferred across a unit of surface in unit time to the concentration gradient perpendicular to that surface, and is characteristic both of the diffusing substance (usually called the "solute" in liquid systems) and of the medium in which it diffuses.

Diffusivities are used in chemical engineering for many calculations involving the correlation, interpretation and design of such common mass-transfer processes as distillation, absorption and extraction. Comparatively few diffusivity data have been published, however, and reliable prediction and extrapolation procedures often prove to be quite valuable.

The units of D are usually given as cm.^{2}/sec., as used in this article.

We'll discuss mutual and self-diffusion coefficients of gases first; then we'll consider liquids, for which we must distinguish between dilute and concentrated solutions of both electrolytes and nonelectrolytes.

Methods for Gases

Mutual diffusion coefficients of most binary gas systems are in the range of 0.05 to 1.0 cm.^{2}/sec., for the temperature range 300-400 K.

The simple kinetic theory of gases predicts qualitative behavior, i. e., diffusion is more rapid at high temperatures because of higher

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molecular speeds, and at low pressures because average intermolecular distances are greater and collisions are less frequent. Also, smaller molecules diffuse more rapidly because of their greater speeds and because the probability of collisions (collision "cross section") is lower than for large molecules.

Earliest theoretical work—which includes most of the basic foundations of the present-day theory of diffusion in gases—was done by Fick,[2] Stefan,[3] and Maxwell.[4] Additions to the general theory have since been made by Sutherland,[5] Meyer,[6] Jeans,[7] Enskog,[8] Chapman and Cowling[9] and by Hirschfelder and his coworkers.[10] (Reference 10 gives the four sources where this work is best reviewed in its entirety.)

The various theories which these investigators have produced often differ in the predicted variation of $(D_V)_{1,2}$ with composition of the gas mixture. Meyer's expression, as modified by Jeans,[7] allows a maximum variation of 33%, which is a far stronger dependence than indicated by all available experimental data for binary gas mixtures; these show a variation of only 2–3% for most gas pairs and a maximum variation of 8–9%. This variation depends principally on the relative magnitudes of the molecular weights of the components of the system.

Unless this difference is very large, the influence of composition on D_V is small enough to be disregarded for engineering calculations. Should such a correlation be deemed necessary, you might consult Hirschfelder's book[10] or the approximation graph used by Wilke and Lee.[11]

Nomenclature

A	A constant; or "abnormality" factor.
b, B	Constants.
C	Sutherland constant (gas), deg. K; or molar liquid-phase concentration gram-moles/cc.
d	Differential operator.
D	Diffusion coefficient, cm.²/sec.
e	2.713
F	A factor in Eq. (9).
F'	The group $(T/D_L\mu)$ for liquid-phase diffusion.
k	Boltzmann's constant, ergs/deg. K.
M	Molecular weight.
N	Molar rate of diffusion, gram-moles/sec.-cm.²; or Avogadro's number.
P	Total pressure, atm. abs.
r	Radius of solute molecule.
t	Temperature, deg. C.
T	Absolute temperature, deg. K.
u	Valence of cation.
U	Ionic velocity of cation at infinite dilution, cm./sec.-dyne.
v	Valence of anion.
V	Ionic velocity of anion at infinite dilution, cm./sec.-dyne; or molecular liquid volume at T_b, cc./gram-mole.
z	Path length for diffusion, cm.
ϵ	Maximum energy of molecular attraction, ergs.
μ	Liquid viscosity, centipoises [but gram-sec./cm. for gas in Eq. (12)].
ρ	Density, grams/cc.
σ	Low-velocity collision diameter, in Angstrom units; or surface tension.
ϕ_D	Collision function for molecular diffusion.

Subscripts

b	At the normal boiling point.
c	At the critical point.
L	For liquid.
V	For vapor or gas.
1 & 2	For gases, denotes components 1 and 2, respectively; for liquids denotes solute (diffusing) and solvent, respectively.
1, 1	Denotes self-diffusion.
1, 2	For a binary system.

Method 1—Hirschfelder

Hirschfelder and his coworkers have used the empirical Lennard-Jones potential energy function for spherical, nonpolar molecules to derive expressions for the equation of state and transport coefficients of pure gases and gas mixtures at low and moderate densities.

By neglecting the composition correction factor, as discussed above, the expression for mutual gas diffusivity becomes:

$$(D_V)_{1,2} = A\,T^{1.5}b/P\sigma_{1,2}^{2}\phi_D \qquad (1)$$

where

$$b = [(M_1 + M_2)/M_1\phi_2]^{0.5}$$

and where the constant A has a theoretical value of 0.0009292; ϕ_D, the collision function is a function of $kT/\epsilon_{1,2}$; ϵ is the maximum energy of attraction; and k is Boltzmann's constant.

The adjustable parameters or force constants, σ and ϵ/k, are best calculated from data on gas viscosity as a function of temperature. See any part of Ref. 10 for details. In the absence of such information, these constants are best estimated for the pure components from the following relations as demonstrated by Wilke & Lee:[11]

$$\sigma = 1.18V^{0.333} \qquad (2)$$

$$\epsilon/k = 1.21T_b \text{ or} \qquad (3)$$

$$\epsilon/k = 0.75T_c$$

Molecular volume, V, in Eq. (2) and elsewhere in this article should be calculated by summing the atomic contributions at the boiling point. For values, see Table I.

For gas mixtures, the following combining laws should be used:

$$\sigma_{1,2} = 0.5(\sigma_1 + \sigma_2) \qquad (4)$$

$$\epsilon_{1,2}/k = (\epsilon_1\epsilon_2/k^2)^{0.5} \qquad (5)$$

Wilke & Lee[11] also found that accuracy could be improved if the following empirical representation of A is used, instead of a single theoretical value:

$$A = 10.7 - 2.46[(M_1+M_2)/M_1M_2]^{0.5} \qquad (6)$$

The functional dependence of ϕ_D on kT/ϵ is given in Table II, which we have partially reproduced from Ref. 10.

Thus, the sequence of calculations using the Hirschfelder method is as follows:

1. Calculate σ for each of the pure components using Eq. (2).
2. Calculate $\sigma_{1,2}$ for the binary system using Eq. (4).

3a. Calculate ϵ/k for each pure component using Eq. (3).

3. Use Eq. (5) to get $\epsilon_{1,2}/k$ for the binary system.
4. Select ϕ_D from Table II.
5. Calculate A from Eq. (6).
6. And finally, calculate $(D_V)_{1,2}$ using Eq. (1).

Although many gases do not fulfill completely the assumptions upon which Eq. (1) is based, it may nevertheless be used with good accuracy since errors will tend to cancel to some extent.

When the small concentration correction was included, Wilke & Lee[11] found that Eq. (1) gave average and maximum deviations of 7.7% and 24.5% for 64 systems, when the force constants were evaluated from Eqs. (2) and (3). With force constants determined from viscosity data, the deviations decreased to 3.9% and 16.0%. Force constants calculated from viscosity data and the Lennard-Jones 6-12 potential have been listed for 52 gases in Refs. 10 and 12. We have shown these force constants for a dozen common gases in the low-temperature range in Table III.

Fair & Lerner[13] have developed a generalized graphical correlation of binary gas-diffusion coefficients which is based on some of the relations given above and the theorem

of corresponding states. Three new quantities—a critical diffusion coefficient, a reduced diffusion coefficient and a "barrier-gas ratio"—are defined and used in the correlation.

This graphical method appears to be almost as accurate as the method described above. However, the graphical approach, with its attendant simplicity and speed (once one becomes familiar with the techniques) would probably be desirable only if many diffusivities were to be evaluated.

Method 2—Arnold's Approach

Arnold[14] followed Sutherland's general approach[5] and developed a prediction equation for D_v that, for all practical purposes, is as accurate as Eq. (1) used with estimated force constants.

His procedure involves two equations:

$$(D_V)_{1,2} = \left[\frac{0.00837b^{0.5}}{P(V_1^{0.333} + V_2^{0.333})^2}\right] \times [T^{2.5}/(T + C_{1,2})] \quad (7)$$

where $b = (M_1 + M_2)/M_1M_2$

and where $C_{1,2}$ is the Sutherland constant for diffusion in deg. K., for the binary system.

Values for $C_{1,2}$ may be calculated from:

$$C_{1,2} = 1.47F(T_{b1}T_{b2})^{0.5} \quad (8)$$

$$\text{where } F = \left[\frac{2(V_1^{0.333}V_2^{0.333})^{0.5}}{(V_1^{0.333} + V_2^{0.333})}\right]^3 \quad (9)$$

Eq. (9) is stated differently in the original reference,[14] and is in error there. The F factor calculated from Eq. (9) is generally close to unity, decreasing from unity as the difference of component molecular volumes increases. Here are some typical values:

V_2/V_1	F
1.0	1.00
2.0	0.98
3.0	0.95
4.0	0.92
5.0	0.89
6.0	0.88
8.0	0.84
10	0.81

In their comparison, Wilke & Lee[11] obtained average and maximum deviations of 8.4% and 20.5% when Eqs. (7) to (9) were applied to 64 systems.

Method 3—Gilliland Equation

Gilliland's often-used equation[13] for gas diffusivity, Eq. (10), is based on the hard-sphere model of classical kinetic theory.

Structural Contributions at the Normal Boiling Point—Table I

Molecular Volumes

Air	29.9	CO_2	34.0	H_2S	32.9	NO	23.6
Br_2	53.2	COS	51.5	I_2	71.5	N_2O	36.4
Cl_2	48.4	H_2	14.3	N_2	31.2	O_2	25.6
CO	30.7	H_2O	18.85	NH_3	25.8	SO_2	44.8

Atomic Volumes

As	30.5	F	8.7	P	27.0	Sn	42.3
Bi	48.0	Ge	34.5	Pb	48.3[a]	Ti	35.7
Br	27.0	H	3.7	S	25.6	V	32.0
C	14.8	Hg	19.0	Sb	34.2[b]	Zn	20.4
Cr	27.4	I	37.0	Si	32.0		

Cl, terminal, as in RCl	21.6	in higher esters, ethers	11.0
medial, as in R·CHCl·R	24.6	in acids	12.0
Nitrogen, double-bonded	15.6	in union with S, P, N	8.3
triply bonded, as in nitriles	16.2[c]	3-membered ring, deduct	6.0
in primary amines, RNH_2	10.5	4-membered ring, deduct	8.5
in secondary amines, R_2NH	12.0	5-membered ring, deduct	11.5
in tertiary amines, R_3N	10.8[d]	6-membered ring as in benzene, cyclohexane, pyridine, deduct	15.0
Oxygen, except as noted below	7.4	Naphthalene ring, deduct	30.0
in methyl esters	9.1	Anthracene ring, deduct	47.5
in methyl ethers	9.9		

NOTES—Data are those of Le Bas as reported in "The Molecular Volumes of Liquid Chemical Compounds," Longmans London (1915). a—An average value for Pb. b—An estimated value. c—Determined by author from available data. d—Determined by author from very limited data.

Calculated Values for the Collision Function—Table II

$kT/\epsilon_{1,2}$	ϕ_D	$kT/\epsilon_{1,2}$	ϕ_D	$kT/\epsilon_{1,2}$	ϕ_D
0.30	1.331	1.65	0.5767	4.0	0.4418
0.35	1.238	1.70	0.5701	4.1	0.4394
0.40	1.159	1.75	0.5639	4.2	0.4370
0.45	1.092	1.80	0.5580	4.3	0.4347
0.50	1.033	1.85	0.5523	4.4	0.4326
0.55	0.9829	1.90	0.5471	4.5	0.4305
0.60	0.9383	1.95	0.5421	4.6	0.4284
0.65	0.8991	2.0	0.5373	4.7	0.4265
0.70	0.8644	2.1	0.5284	4.8	0.4246
0.75	0.8335	2.2	0.5203	4.9	0.4228
0.80	0.8058	2.3	0.5129	5.0	0.4211
0.85	0.7809	2.4	0.5061	6	0.4062
0.90	0.7585	2.5	0.4998	7	0.3948
0.95	0.7382	2.6	0.4939	8	0.3856
1.00	0.7197	2.7	0.4885	9	0.3778
1.05	0.7028	2.8	0.4836	10	0.3712
1.10	0.6873	2.9	0.4788	20	0.3320
1.15	0.6731	3.0	0.4745	30	0.3116
1.20	0.6601	3.1	0.4703	40	0.2980
1.25	0.6479	3.2	0.4664	50	0.2878
1.30	0.6367	3.3	0.4628	60	0.2798
1.35	0.6263	3.4	0.4593	70	0.2732
1.40	0.6166	3.5	0.4560	80	0.2676
1.45	0.6075	3.6	0.4529	90	0.2628
1.50	0.5991	3.7	0.4499	100	0.2585
1.55	0.5912	3.8	0.4471	200	0.2322
1.60	0.5837	3.9	0.4444	300	0.2180

Note—Values selected from Trans. ASME, Vol. 72, p. 925 (1949).

Force Constants From Viscosity, Selected Gases—Table III

	σ, In Angstroms	ϵ/k, Deg. K.		σ, In Angstroms	ϵ/k, Deg. K.
Air	3.617	97.0	SO_2	4.290	252
N_2	3.681	91.5	F_2	3.653	112
O_2	3.433	113	Cl_2	4.115	357
CO	3.590	110	HCl	3.305	360
CO_2	3.996	190	C_6H_6	5.270	440
CH_4	3.882	137	C_2H_5OH	4.455	391

$$(D_V)_{1,2} = \frac{0.00437\,T^{1.5}b^{0.5}}{P(V_1^{0.333} + V_2^{0.333})^2} \quad (10)$$

where once again,

$$b = (M_1 + M_2)/M_1M_2$$

The empirical constant of Eq. (10) was deliberately chosen to give somewhat low values of D_V, thus compensating for the probability that some experimental values are too large because of the difficulty in eliminating convection in gas diffusivity experiments.

Wilke & Lee[11] found average and maximum deviations of 20.0% and 46.8% for Eq. (10) when it was applied to 64 selected systems. Another weakness of Eq. (10) is that $T^{1.5}$ does not ordinarily correlate temperature dependency of D_V satisfactorily; the exponent usually varies between 1.6 and 2.2.

Method 1 and Method 2 allow for this variation of effective temperature exponent, and would be expected to be much superior to Eq. (10) at high temperature levels.

Multicomponent Gas Mixtures

In multicomponent systems the diffusivities are highly dependent on composition and are different for each component.

A rigorous theory of multicomponent mixtures[16] gives complicated expressions for diffusion coefficients in gases containing more than two components. An approximate approach proposed by Wilke[17, 18] may be used for calculating effective diffusion coefficients of components with respect to the total gas mixture for the case of diffusion of one gas into a mixture of stagnant gases:

$$(D_V)_1' = \frac{1 - y_1}{\frac{y_2}{D_{1,2}} + \frac{y_3}{D_{1,3}} + \cdots} \quad (11)$$

where y with subscripts 1, 2, 3, etc., are mole fractions of components 1, 2, 3, etc.; and D with subscripts 1, 2; 1, 3; etc., are the binary diffusion coefficients of Component 1 with respect to each component of the mixture.

Limited testing of Eq. (11) indicates that it is capable of predicting $(D_V)_1'$ as a function of composition within 5 to 10%. At any rate, this method is much superior to the assumption of diffusivities additive on a mole-fraction basis.

Data of Burnside[19] on ammonia, propylene and diethyl ether in air indicate that constancy of the $D_V\rho$ product holds up to 30 atm. total pressure.

Data of Becker, Vogell & Zigan[20] for the self-diffusion of nitrogen and carbon dioxide show the $D_V\rho$ product for nitrogen to be constant for pressures between 20 and 90 atm.; for carbon dioxide, the variation of $D_V\rho$ over the range of 14 to 52 atm. was 30%, probably because of dimerization. Chou & Martin in *Ind. & Eng. Chem.*, Vol. 49, p. 758 (1957), found $D_V\rho$ constant for hydrogen-carbon dioxide at low temperature for pressures up to about 225 atm.

It would appear that Eqs. (1), (7) and (10), which all show $D_V\rho$ to be constant for pressure change, would be satisfactory in this respect for pressures less than about 500 psia.

Self-Diffusion Coefficients

A limiting case of diffusion is that of a substance diffusing through itself. This is called self-diffusion.

The self-diffusion coefficient is usually denoted by $D_{1,1}$ to distinguish it from the mutual diffusivity, $D_{1,2}$. $D_{1,1}$ is a somewhat artificial quantity and may be considered only as a limit of $D_{1,2}$. Although there are no engineering applications at present, self-diffusion is sometimes used in studies of intermolecular-force behavior.

Experimental measurements of self-diffusion necessitate the use of isotopic tracers or ortho-para forms, since it is obviously impossible to measure inter-diffusion if all molecules are truly identical.

Method 1—Reciprocal Schmidt No.

Kinetic theory predicts that for all expected types of interaction between gas molecules, the reciprocal Schmidt number formed with self-diffusivity,

$$\rho_V\,(D_V)_{1,1}/\mu_V$$

will fall between 1.200 and 1.543. Experimental data for nine substances lie between 1.24 and 1.48.

The prediction, then, is that reciprocal Schmidt number is equal to 1.35, within about plus or minus 10%. This may be transformed to:

$$(D_V)_{1,1} = 1.35\mu_V/\rho_V \quad (12)$$

Method 2—From Force Constants

Hirschfelder and coworkers[10, 12] have shown that Eq. (1), when written for the case of self-diffusion (where $M_1 = M_2$; $\epsilon_{1,2} = \epsilon_1 = \epsilon_2$; and $\sigma_{1,2} = \sigma_1 = \sigma_2$) becomes:

$$(D_V)_{1,1} = \frac{0.001314\,T^{1.5}}{P\sigma^2M^{0.5}\phi_D} \quad (13)$$

This first approximation differs from the second approximation by less than 1%. The usual force constants (Eqs. (2) and (3), or Table III) are used in Eq. (13). ϕ_D is the same collision function for diffusion given in Table II.

Comparisons with experimental data[10] for eight gases between 20 and 295 K., and at 1 atm. pressure or less, indicate average and maximum deviations for Eq. (13) of 6.6% and 27.9%.

The Hirschfelder-Bird-Spotz general theory predicts an average reciprocal Schmidt number for gases of about 1.32, in close agreement with empirical Eq (12) given previously.

The Enskog dense-gas theory [8, 12] permits calculation of $(D_V)_{1,1}$ to quite high pressures.

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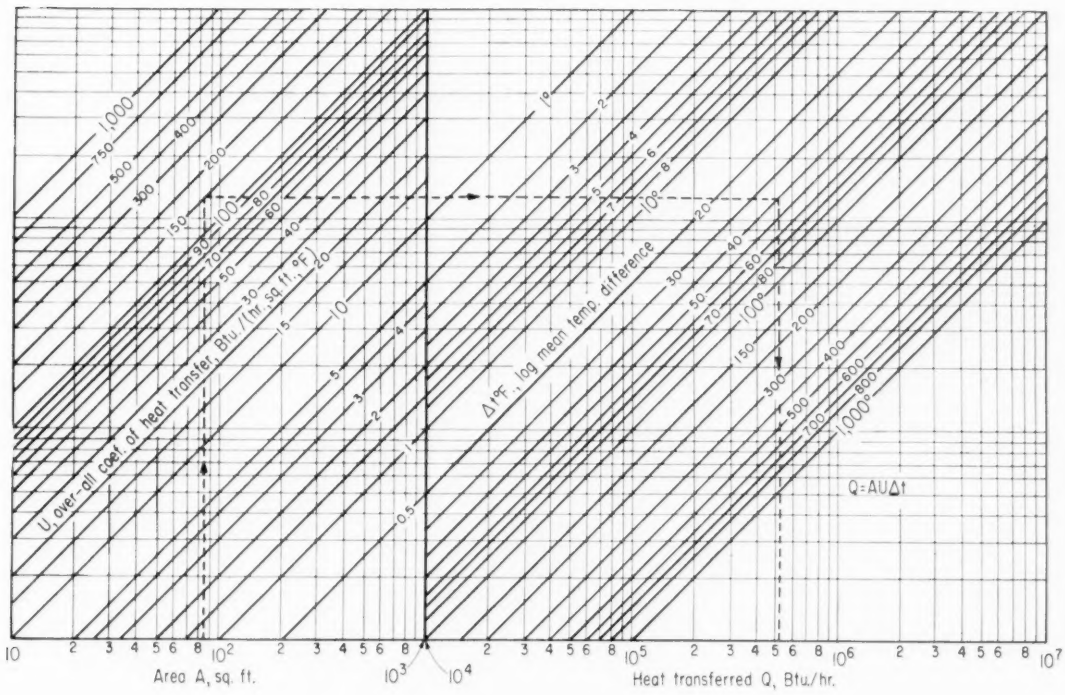


Chart Visualizes Heat Transfer Relations

Relations between heat transferred, area, transfer coefficient and temperature difference are readily apparent

Edward J. Gibbons
Mechanical Engineer, New York, N. Y.

The accompanying chart is useful in the design of heat transfer equipment since it not only solves the heat transfer equation, $Q = A\ U\ \Delta t$, but readily enables the engineer to visualize the relations between these four quantities.

In the equation Q is heat transferred, Btu./hr.; A is area of transfer surface, sq. ft.; U is over-all coefficient of heat transfer, Btu./(hr., sq. ft., °F. Δt); and Δt is log mean temperature difference, °F.

The visualizing possibilities of the chart show to best advantage when a series of calculations has to be made for an optimum solution. The particular case shown on the chart is for an 85-sq. ft. heater with a U value of 150 at a log mean Δt of 40 F., permitting transfer of 510,000 Btu./hr.

If the amount of heat to be transferred is known, and the needed surface is to be determined, the process can be reversed, starting with the heat load and ending with the surface.

When both the area and the heat load are known, the chart makes it simple to arrive at a series of Δt's and U's, each set of which will be a solution to the problem. Conversely, with the load and heat transfer coefficient known, it is easy to find the various coincident values of Δt and A which will transfer the required amount of heat.

Calculate Logs From Simple Series

W. A. Mason
Stockton-on-Tees
County Durham, England

If you can remember the proportions of the sides of a right triangle, 4-3-5, you can write down a table of logarithms which will be surprisingly accurate.

First, scale the proportional lengths down to 1/40th to obtain 0.1-0.075-0.125. Proceeding around the triangle several times

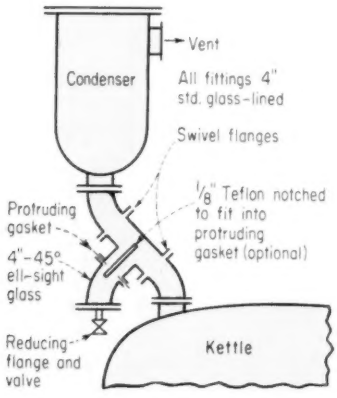
Number	Log	Calc. No.	Calc. Log
1	0	4×2^{-2}	0
1.25	0.1	5×2^{-2}	0+0.1
1.5	0.175	3×2^{-1}	0.1+0.075
2.0	0.3	4×2^{-1}	0.175+0.125
2.5	0.4	5×2^{-1}	0.3+0.1
3.0	0.475	3×2^{0}	0.4+0.075
4.0	0.6	4×2^{0}	0.475+0.125
5.0	0.7	5×2^{0}	0.6+0.1
6.0	0.775	3×2^{1}	0.7+0.075
8.0	0.9	4×2^{1}	0.775+0.125
10.0	1.0	5×2^{1}	0.9+0.1

and taking the accumulative totals gives the log series, thus: 0; 0 + 0.1 = 0.1; 0.1 + 0.075 = 0.175; 0.175 + 0.125 = 0.300; etc. Note the second and fourth columns in the table which show respectively the logs and the method of calculating them.

Now, to get the numbers corresponding to these logs note that the terminal numbers of the series must be 1 and 10. To fill in the intervening numbers again resort to the triangle. Each number equals one side of the triangle multiplied by some power of 2.0. Going around the triangle in the opposite direction, start with $4 \times 2^{-2} = 1$; $5 \times 2^{-2} = 1.25$; $3 \times 2^{-1} = 1.5$; $4 \times 2^{-1} = 2.0$; $5 \times 2^{-1} = 2.5$; . . . $5 \times 2^{1} = 10.0$. Note that every fourth term is twice the first.

The series can be extended in either direction, e.g., log 0.75 = −0.125; and log 12 =1.075. Logarithms of intermediate numbers can be obtained by regular calculation procedures, e.g., log 9 = log (3^2) = 2 × 0.475 = 0.950.

This method provides a more convenient series for drawing logarithmic graphs on linear paper than does that of Volff (*Chem. Eng.*, p. 262, June 1956). It also supplies an aid to memory for the series of logarithmic scales presented by Grogan (*Chem. Eng.*, p. 212, May 1955).

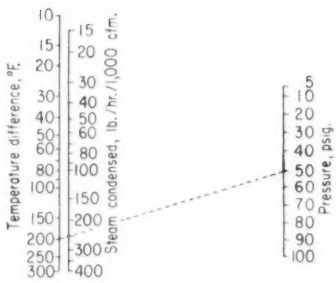


Versatile Reflux System For Distillations

William T. Klapper
Chemical Engineer,
Bloomfield, N. J.

In our pilot plant we had the problem of separating water from refluxing benzene. The equipment shown, a variation of the Dean Stark apparatus, worked exceptionally well despite its apparent simplicity. Water had to be drawn from the valve at intervals of 5 to 20 min., but this was preferred to continuous gravity separation. The benzene returned to the kettle at practically reflux temperature.

Without any change we also used this equipment for distilling off solvents contaminated with non-volatiles, simply removing the distillate through the valve under the sight glass. When we used the equipment for distilling non-azeotropic mixtures, we merely loosened the flanges on the tee, pointed it up instead of down, and re-tightened the flanges. Thus the 45° elbows still served the useful purpose of getting the condenser away from the kettle agitator. This set-up consisted of Pyrex glass and glass-lined pipe fittings but the same idea should work equally as well in metal.



Nomograph Gives Steam Condensed by Air

Y. P. Varshni
Allahabad University
Allahabad, India.

In determining the steam required for air heating and also in selecting the right size of steam trap for such applications, the accompanying nomograph is decidedly a handy calculation time-saver.

It is intended for applications where air is heated by being blown over steam coils. It is based on data given by Campbell (*Chem. Eng.*, p. 230, Jan. 1957). However, the data can easily be calculated on the assumption that 0.0192 Btu. will heat 1 cu. ft. of saturated air through 1 F. at 32 F., using the latent heat of steam at various supplied pressures.

To use the chart connect the necessary temperature rise (200 F.) with the steam pressure (50 psig.) and find 250 lb./(hr., 1,000 cfm.) from the intersection. The true value is actually 252 lb.

NEXT ISSUE: Watch for May Winner Announcement

★ How Readers Can Win

$50 Prize for a Good Idea—Until further notice the Editors of *Chemical Engineering* will award $50 each four weeks to the author of the best short article received during that period and accepted for Plant or Design Notebook.

Each period's winner will be announced in the second following issue and published in the third or fourth following issue.

$100 Annual Prize—At the end of each year the period winners will be rejudged and the year's best awarded an additional $100 prize.

How to Enter Contest—Any reader (except a McGraw-Hill employee) may submit as many contest entries as he wishes. Acceptable material must be previously unpublished and should be short, preferably not over 500 words, but illustrated if possible. Acceptable non-winning articles will be published at space rates ($10 minimum).

Articles should interest chemical engineers in development, design or production. They may deal with useful methods, data, calculations. Address Plant & Design Notebooks, *Chemical Engineering*, 330 W. 42nd St., New York 36, N. Y.

When 2,000 chemical engineers were asked:

Q. "Is There a Shortage of Engineers Today?"

Here is what they said:

	Replies	%
We are faced with an alarming shortage	65	4.0
There is some, but not an undue shortage	873	54.0
There are just about enough engineers	428	26.5
We have somewhat more than we need	154	9.5
The growing excess is a threat to job security	57	3.5
Not stated	41	2.5
Total replies	1,618	100.0

A. "There Is No Undue Shortage of Engineers."

Lately it seems that everybody and his brother has been focusing his attention on the supply and demand of engineers.

Economists and scientists have done it. Management consultants have done it. Engineers themselves —through Engineers Joint Council —have done it. Government has done it. And even engineering editors have done it.

All this activity does serve some useful purpose. It helps stimulate the growing public awareness that engineering is indeed a noble calling. But awareness is not enough. We need some facts; or in their absence, we need the best of all possible theorizing in this, the best of all possible worlds. (My apologies to Candide.)

Ask the Man Who Owns One

We ourselves have done some thinking about the supply and demand situation for chemical engineers. Most of the surveys that we have read deal with engineers and scientists in general.

Some of these surveys try to break down the "statistics" into branches of engineering. Some succeed, some fail. But nowhere can you find a good survey on chemical engineers.

That is, nowhere except in the study that we are now going to describe.

Who would know better than anyone else whether there is or is not a shortage of chemical engineers? Would you ask employers, personnel managers, recruiters, colleges; or would you go and ask chemical engineers themselves?

We would prefer to ask chemical engineers.

Enter Erdos and Morgan

On Jan. 29th the Erdos and Morgan Research Service, New York, sent the following letter to 2,000 carefully selected chemical engineers:

"We are conducting a survey among leading chemical engineers to find out how they feel about the number of chemical engineers available to U. S. industry today. As you know, the question of whether there is an adequate number of trained scientists and professional men is a much-discussed issue today and we would like to find out the opinions of the groups involved instead of accepting the conclusions of laymen.

"It will take but a moment of your time to answer the few questions asked and to return the questionnaire in the enclosed stamped envelope. Of course your answers will be confidential and will be used only to obtain a composite picture of the profession."

To Stimulate Replies

The questionnaires were sent out over the signature of Dr. Paul L. Erdos. To attract attention and to stimulate replies a bright, new

25-cent piece was attached to each questionnaire. A postscript read: "The small coin enclosed is intended not as payment, but as a token of our appreciation for your help."

By March 3rd, when the survey closed, 1,618 usable replies were received. Another 33 were either returned by the post office as undeliverable or were answers from retired chemical engineers. These 33 were eliminated from the total sample, leaving a net mailing of 1,967.

The 1,618 tabulated answers represent an 82.3% return.

Exact Wording Important

In any survey such as this, the wording of the question can be rather critical. What was wanted was an expression of opinion on the supply-and-demand situation for chemical engineers specifically. That's why the question was worded this way:

"Here are several statements about the number of chemical engineers in the U. S. Please check the one which most closely approximates your own thinking on the subject."

Respondents were offered this choice of reply:

1. We are faced with an alarming shortage of engineers.
2. There is some, but not an undue shortage of engineers.
3. There are just about enough engineers.
4. We have somewhat more engineers than we need.
5. The growing excess of engineers constitutes a threat to job security in the profession.

The tabulated replies and percentages are shown on the previous page.

A Possible Flaw

Although the question was worded carefully, the wording of the answers may leave something to be desired.

The question was specific for chemical engineers. However, by repeating the nonexclusive phrase "engineers" in each of the answers, it's entirely possible that some respondents were thrown off guard. They may have answered the question in terms of all engineers, rather than in terms of chemical engineers in particular.

Draw Your Own Conclusion

In spite of this possible flaw, it's not difficult to draw some forceful conclusions from the answers to the question.

First, only 4% of the respondents agree with the President's Committee on Scientists and Engineers that we now have an "alarming shortage of engineers."

By combining choices 1 and 2, 58% agree that there is some shortage. But most now feel that there is no undue shortage.

Those who selected options 3, 4 or 5 indicate that about 40% are of the opinion that we have enough chemical engineers now; with 10% saying that we have more than we need. Some took an even stronger stand, with 57 replies suggesting that the growing excess of engineers constitutes a threat to job security in the profession.

We are sure that other combinations of the statistics can produce almost any desired conclusion, depending on who wants to use the survey results to prove his own point. Editorially we line up with the middle-of-the-roaders. When you narrow the field to chemical engineers, it will be hard to convince us that there is any alarming shortage today.

A POEM

Alas and alack
I'm a sad sack
And a leading chemical engineer.
It seems to me there are too many;
But not TOO many or job I would have not any.
I'm a leading chemical engineer.

I'm a "two-bit" item
With Erdos and Morgan,
And a leading chemical engineer.
Oh for the day that of me there aren't enough,
I just love that green folding stuff.
I'm a leading chemical engineer.

Take your quarter back and buy a crystal ball.
Tell me, Dr. Erdos, "Will I be short or will I be plenty?"
If it's short enough, my opinion will cost you twenty.
Because I'm a leading chemical engineer.

Astounding Write-In Vote

One of the astounding byproducts of this survey was what may be called the "write-in vote." We took the trouble of transcribing all of the comments that were written in on the questionnaires.

What we described to our transcribing department as "a rather uncomplicated job," managed to generate 49 single-spaced typewritten pages. Many of the respondents vented their emotions at length.

One reply was obscene and had to be left out of the tabulation. Another was sincere, witty and poetic. We have reproduced this literary effort, elsewhere on this page, because we appreciate the spirit in which it was written; and because the respondent was one of several who sent back the 25¢.

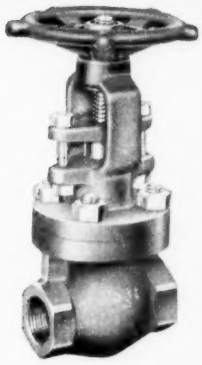
Quality vs. Quantity

The generated responses took off in many directions, but even so, certain over-all patterns appeared. Those who voted for the shortage, in many cases, went on to explain that they felt the shortage was one of quality and not of quantity.

Most flattering was the experience of having several respondents unknowingly quote our own words back to us. Several wrote in paragraphs that first appeared in "Straight Facts on the 1958 Job Outlook," *Chem. Eng.*, Mid-November 1957, p. 479.

Many wrote that engineers are being misused by management, or complained about the lack of professional status for chemical engineers; or blamed the shortage on maldistribution of personnel with too little sub-professional, clerical and/or secretarial help. There were many critics of salaries paid to other than recent graduates.

We've saved our favorite reply for last. "There is a shortage of good engineers, good chemists, good mechanics, good cooks, good—you name it. I can think of only a few callings in which there appears to be no shortage: lobbyists, promoters, ad men, racketeers, thieves and self-appointed experts on what the nation needs and wants."



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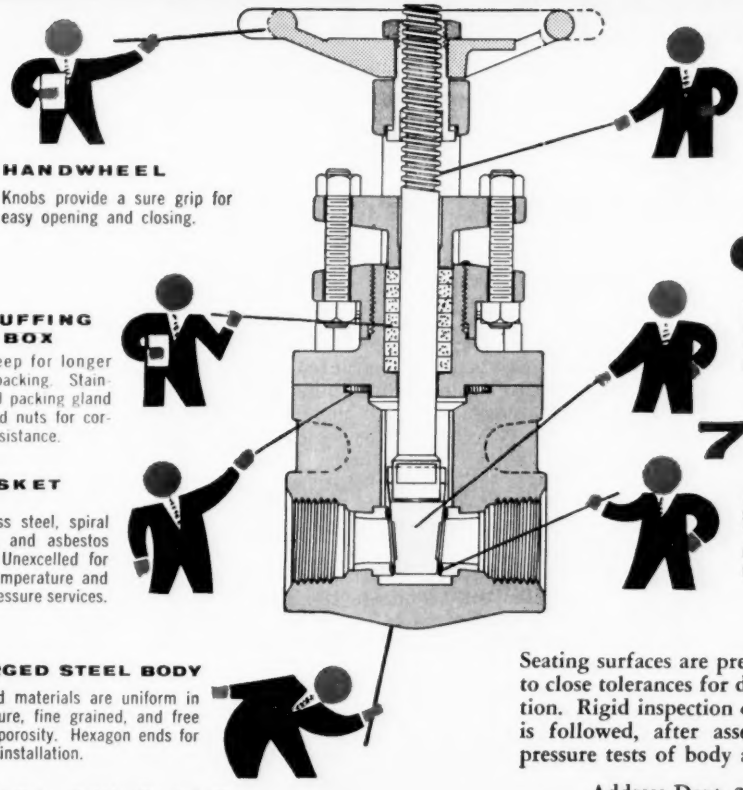

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	Tensile strength, 1,000 psi.								
80 F.	192	196	193	200	215	240	146	86	...
600 F.	162	...	...	...	207	205	140	75	...
700 F.	...	158	156	190	...	...	...	...	...
800 F.	145	...	...	...	197	182	138	...	154
900 F.	...	140	124	164	...	...	...	73	...
1,000 F.	94	99	...	105	...	130	131	...	102

High-strength precipitation-hardening stainless—made by a simple heat treatment—stands up to high temperature, corrosive chemical process conditions.

New Alloy Steels Beat Process Bugaboos—II

D. B. Roach and A. M. Hall, Battelle Memorial Institute, Columbus, Ohio

A new group of stainless steels, known as precipitation-hardening (PH) steels, holds great promise in chemical process applications.

The PH steels combine high strength with corrosion resistance. These properties are produced by a simple heat treatment.* All these steels contain elements such as Al, Cu, Mo, which "precipitate" during the hardening treatment.

Prior to development of the new steels that combination could only be produced in Cr-Ni steels by cold rolling—limiting high strength to sheets, strips and wire. PH steels are available in wrought and cast form.

While not specifically designed for severe corrosive applications, these steels combine the good corrosion resistance of the 17% Cr, 7% Ni Type 301 stainless with the attractive strength properties of the 400 series.

PH steels may be grouped into three basic classes, as follows:

* For a discussion of the new low-carbon steels, see *Chem. Eng.*, May 19, 1958, pp. 180-184.

• Class 1. Those which are martensitic (magnetic), both as annealed and as hardened, and can be hardened by a single heat treatment.

• Class 2. Those which are austenitic (nonmagnetic) as annealed and which require a double heat treatment to harden. They are magnetic in this condition (martensitic).

• Class 3. Those which are austenitic (nonmagnetic) both as annealed and as hardened, and can be hardened by a single heat treatment.

▶ **Wrought Grades** — Nominal compositions of wrought grades are given in the table on page 136. Class 1 steels are available in plate, bar, rod, wire, and forging billets. They are not available in sheet or strip. Class 2 steels are principally sheet and strip products, but are also available as plate, bar, rod, wire, and forging billets. Class 3 steels are generally available in plate, bar, rod, wire, sheet, and strip.

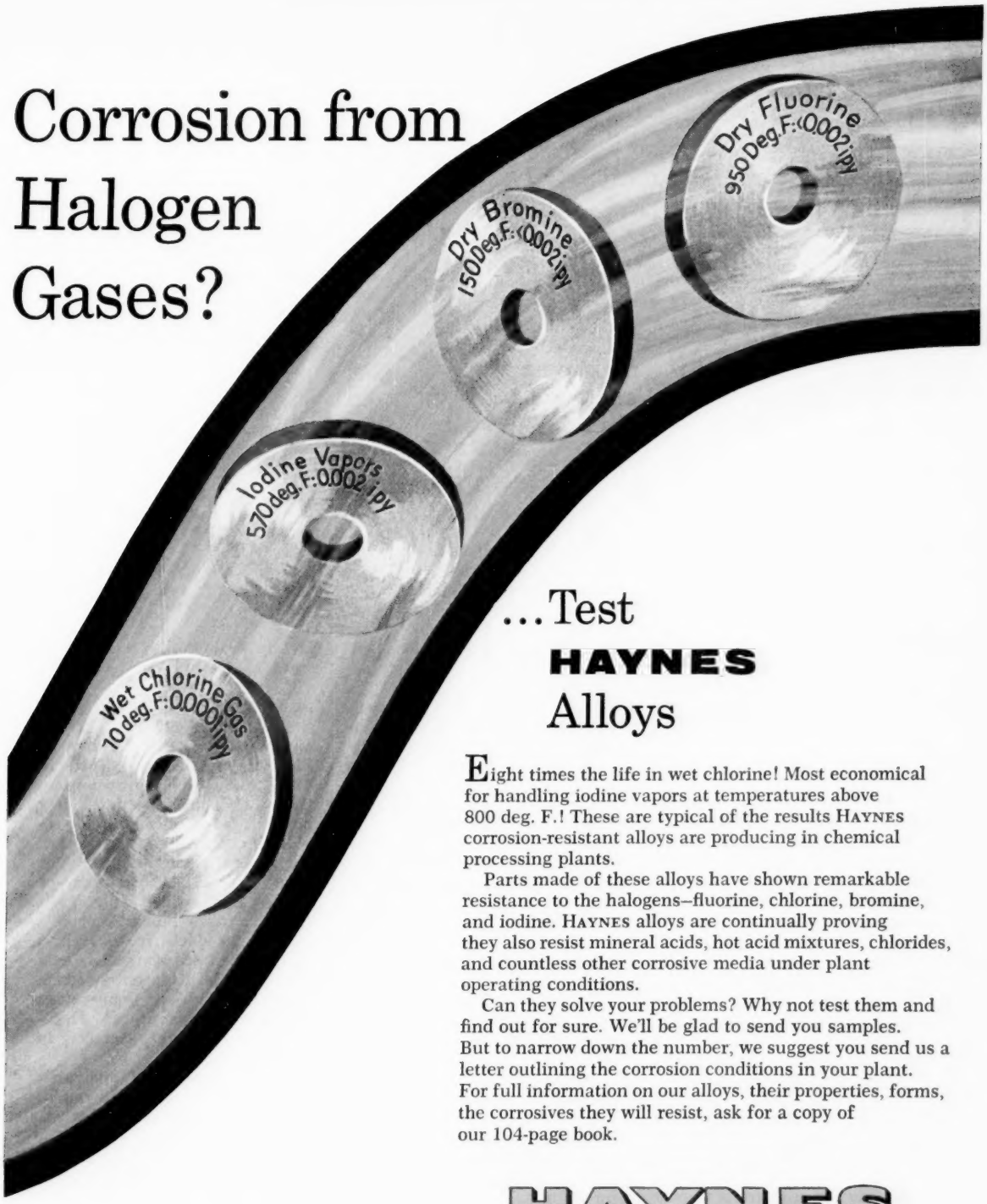
▶ **Good Hot Strength** — Precipitation-hardening stainless steels offer a wide range of mechanical properties (see table above). Those of the first two classes have excellent strength properties at temperatures up to 700 F. The completely austenitic steels do not attain high room-temperature strength properties, but are nonmagnetic and have better strength properties than steels of the first two classes at temperatures of 1,000 F. and above.

Precipitation-hardening stainless steels also offer a wide range in elevated-temperature rupture properties. The alloys of the second class show good rupture properties at temperatures up to 900 F. However, for continual service above 700 F. there is a possible embrittlement problem. The completely austenitic alloys offer good rupture properties up to 1,200 F.

▶ **Resists Corrosion** — The PH stainless steels are not outstanding in resistance to corrosion. Nevertheless, their corrosion resistance is at least equal to, and in many cases much better than, cold-rolled Type 301 stainless.

During the past 10 yr. hundreds of laboratory tests have been conducted on 17-4 PH, 17-7

Corrosion from Halogen Gases?



...Test HAYNES Alloys

Eight times the life in wet chlorine! Most economical for handling iodine vapors at temperatures above 800 deg. F.! These are typical of the results HAYNES corrosion-resistant alloys are producing in chemical processing plants.

Parts made of these alloys have shown remarkable resistance to the halogens—fluorine, chlorine, bromine, and iodine. HAYNES alloys are continually proving they also resist mineral acids, hot acid mixtures, chlorides, and countless other corrosive media under plant operating conditions.

Can they solve your problems? Why not test them and find out for sure. We'll be glad to send you samples. But to narrow down the number, we suggest you send us a letter outlining the corrosion conditions in your plant. For full information on our alloys, their properties, forms, the corrosives they will resist, ask for a copy of our 104-page book.

HAYNES ALLOYS

HAYNES STELLITE COMPANY

Division of
Union Carbide Corporation
Kokomo, Indiana

UNION CARBIDE

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Take Your Pick: PH Steel Compositions (%)

Designation	C	Cr	Ni	Other
Class 1: Martensitic				
Stainless W	0.07	17	7	0.70Al, 0.20Ti
17-4PH	0.04	16.2	4	3.5Cu
Class 2: Semiaustenitic				
17-7PH	0.07	17	7	1.15Al
AM350	0.07	17	4	2.75Mo
AM355	0.13	15.5	4.35	2.75Mo, 0.10N
PH 15-7 Mo	0.07	15	7	2.25Mo, 1.15Al
Class 3: Austenitic				
17–10P	0.12	17	10.25	0.25 P
17–14 Cu-Mo	0.12	16	14	2.5Mo, 3Cu, 0.45Cb, 0.25Ti
HNM	0.30	19	9.5	3.5Mn, 0.30P
A286	0.08 max.	15	25	1.25Mo, 2.0Ti, 0.30V, 0.35 max. Al

PH and PH15-7Mo in many media.** The data indicate that these stainless steels in their heat-treated condition have better resistance than hardened chromium stainless steels. Alloy 17-4 PH is equal to Type 304. However, PH15-7Mo and 17-7 PH show less corrosion resistance in these accelerated tests than Type 304.

Class 1 and 2 types have been used for tanks (with inhibiters) to contain red fuming nitric acid.

The completely austenitic alloys have corrosion resistance about equal to Type 304 in various corrodents.

▶ **Fabrication Pointers** — The martensitic alloys in the annealed condition are hard and not readily punched, cut, blanked, or sheared. Only moderate forming operations are recommended. However, because of their relatively high hardness they are somewhat easier to machine than AISI 302 stainless.

Both are annealed at 1,900 F. for ½ hr. The manner of cooling is usually not critical, although oil or water quenching may cause cracking. Air cooling from the annealing temperature is usually recommended. Aging for maximum strength is accomplished at 950 ±10 F. for 1 hr. for Stainless W and at 900 ±10 F. for 17-4PH. Aging for better ductility is accomplished at higher temperatures up to 1,150 F.

Semiaustenitic alloys are easily punched, sheared, cut, or blanked, although high-grade tool steel dies are required for punching and blanking operations.

As annealed, they are readily formable by conventional techniques used for Type 302 stainless. However, remember the alloys work harden rapidly, so that severe deep-forming operations are undertaken only with intermediate annealing.

In the annealed condition they have better machining characteristics than annealed Type 302. The precipitation-hardening alloys produce chips that break up nicely while Type 302 produces a long stringy chip. Cutting rates are about the same as for Type 302. In the hardened condition, they are machined with more difficulty and require slower speeds.

Semiaustenitic alloys are supplied in the mill-annealed condition (annealed at 1,950 F.). When hardening by double aging the treatment in general consists of heating at 1,400 ±25 F. for 90 min., cooling to 60 F. or below, followed by aging at 850 to 1,050 F.

When hardening by refrigeration (subzero cooling) and aging is planned, a more complex treatment, in which the material is reannealed at 1,750 ±15 F., cooled to −100 F. for 8 hr., and aged at 850 to 1,050 F., is recommended. Annealing can be accomplished in air or in a dry-hydrogen atmosphere.

The completely austenitic types can be punched, sheared, cut, and blanked in the annealed condition. In severe forming operations, they perform in a manner similar to Type 302. Since they have excellent ductility as annealed, many deep forming operations can be accomplished without intermittent annealing. The machining characteristics compare favorably with Type 302.

These alloys are annealed in the relatively high-temperature range of 2,050 to 2,250 F., although A286 is annealed at 1,800 F.

All the austenitic alloys are hardened by aging in the temperature range of 1,200 F. to 1,400 F. for 5 to 24 hr.

▶ **Easy Welding**—Both the martensitic and semiaustenitic grades are readily weldable by any of the arc and resistance processes applicable to stainless steel.

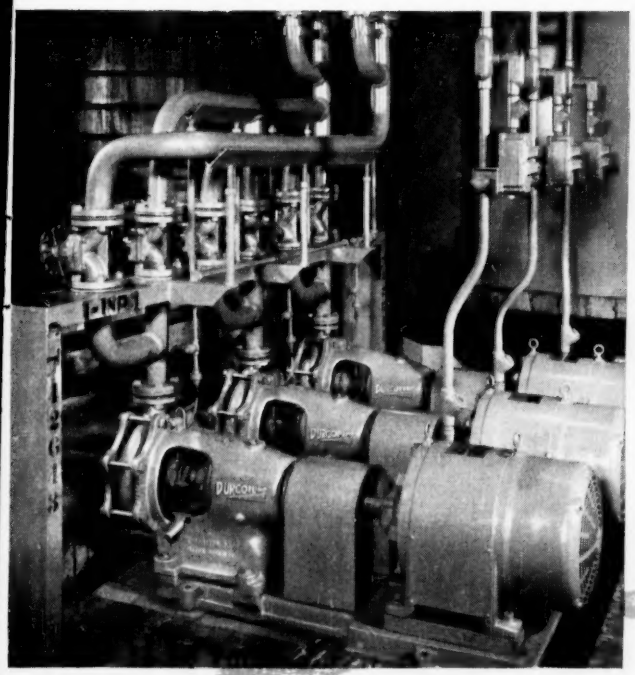
Care must be taken, however, to avoid excessive oxidation of the precipitation-promoting elements, particularly titanium in Stainless W and aluminum in 17-7PH and PH15-7. In addition, the alloys should be completely heat treated after welding to provide high strength properties. All alloys of these two types show joint efficiencies in the range of 95 to 100% when fully heat treated after welding. Some reduction in ductility of welded sections after complete heat treatment is often encountered. Aging at a higher temperature will result in improved ductility with a slight sacrifice in strength.

Of the completely austenitic alloys, only 17-14 Cu-Mo can be successfully welded by the conventional techniques used for stainless steels. Welded specimens of this alloy show somewhat lower stress-to-rupture properties than unwelded specimens. Heat treatment does not noticeably affect the strength of welded joints. The high phosphorus content of 17-10P and HNM makes these alloys very difficult to weld. Neither alloy has been successfully welded as yet. A286 can be welded, but

** Paper on corrosion resistance of high-strength stainless steels delivered by J. Halbig and O. B. Ellis at 1958 conference, National Association of Corrosion Engineers, Mar. 21, 1958.

For reliability in America's great chemical plants

DURCOPUMPS



Durcopumps pictured in service at

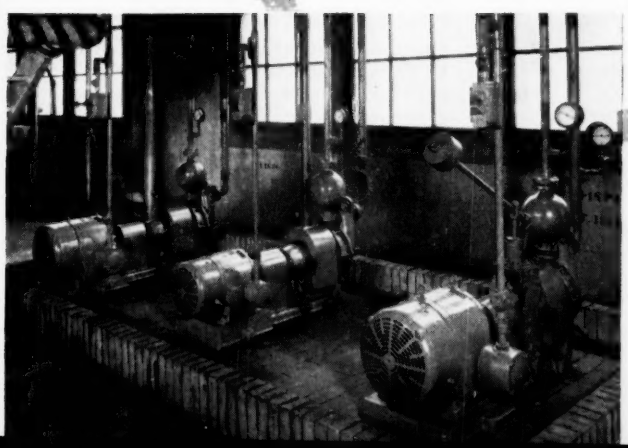
AMERICAN Cyanamid COMPANY

The Bound Brook, New Jersey Plant

The Duriron Company has been serving American Cyanamid Company for many years by providing chemical service equipment to handle their severe corrosives safely and reliably.

The Bound Brook plant of American Cyanamid Company is a primary source of pharmaceuticals, dyestuffs, pigments, rubber chemicals, intermediates, and other products for the chemical processing industry. They use Durcopumps for their process pumps.

We take pride in serving the country's leading industrialists. We are particularly proud that many of the really top companies turn to DURCO first when they have a corrosion problem.



THE DURIRON COMPANY, Inc.
Dayton 1, Ohio

DURCO
CORROSION RESISTING ALLOYS & EQUIPMENT

Composition of Important Cast Precipitation-Hardening Steels (%)

	C	Cr	Ni	Cu	Si	Mn	Other
17-4PH	0.06 max.	15.75-16.75	3.25-4.25	3.50-4.25	0.70 max.	0.70 max.	N—0.045 max.
V2B	0.07 max.	19-19.5	9.7-10.24	2.0-2.25	2.25-3.0	0.50-0.75	Mo—3-3.5; Be—0.1-0.2
CD4MCu	0.04 max.	25-27	4.75-6.0	2.75-3.25	1.0 max.	1.0 max.	.....

only with considerable difficulty.

▶ **Where Are They Used?**—In industrial applications the martensitic and semiaustenitic alloys have been competitive. They have been used as plates, bar, rod, forgings, sheet, strip, and wire. Because of their high strength-to-weight ratio at moderate temperatures up to 600-1,000 F, they are widely used in aircraft.

The completely austenitic alloys have found a somewhat different use pattern. 17-10P is used in applications requiring a combination of moderate strength and low magnetic permeability. The principal use of this alloy has been in naval programs and in oil field instrument applications. In marine use it has been substituted for K-Monel and beryllium-copper with a considerable savings in cost and critical metals.

Alloys 17-14 Cu-Mo, HNM, and A286 have excellent strength properties at temperatures above 1,000 F. and, consequently, they have been suggested for use in aircraft gas turbines, high-temperature steam turbines, boilers, superheaters, petroleum-cracking stills, etc.

▶ **Cast Grades**—There are three cast precipitation-hardening grades which have gained commercial importance. These are Armco's 17-4PH, Cooper Alloy Foundry's V2B Alloy, and the CD4MCu alloy developed for the Alloy Casting Institute. They have gained importance because of their cast properties, particularly their combination of adequate corrosion resistance and high strength, hardness, and galling resistance.

Compositional ranges to which these steels are melted are given in the table. The alloys correspond to the general martensitic type described in the preceding section of this article. Other precipitation-hardening stainless steels, such as Stainless W, AM350, AM355, 17-10P, 17-14 Cu-Mo, and 17-4PH are supplied in the form of castings. However, they have not been produced in large quantities as yet.

▶ **Armco 17-4PH**—This steel is the cast version of the wrought alloy previously discussed. Copper is responsible for precipitation-hardening. If 17-4PH is to be welded, copper should be held between 2.25-3.00%.

Room-temperature mechanical properties of cast 17-4PH (tensile strength is 179,000 psi. for hardened cast) are not quite as high as those developed in wrought 17-4PH. Nevertheless, these properties are quite noteworthy for a cast material.

The alloy is readily weldable by any of the conventional methods used for welding standard stainless steels. A 17-4PH welding rod is available for such operations. No intergranular corrosion embrittlement results from the welding heat. Welded joints must be fully heat treated to produce full strength.

The alloy has good corrosion resistance. It is especially resistant to sea-water corrosion and pitting, and is recommended for use in ship propellers, pump impellers, and other marine applications of a wide variety. In food and chemical industries its use is in mildly corrosive application where strength and galling resistance are required.

▶ **Copper Alloy V2B**—Alloy V2B is a precipitation-hardenable 18-8 type containing copper, molybdenum, silicon, and a small amount of beryllium which is responsible for age hardening. The alloy was designed to give corrosion resistance, approaching that of the molybdenum-bearing Type 316, combined with good strength and galling resistance.

While this alloy does not develop quite the high strength of cast 17-4PH (tensile strength of 151,600 psi. for hardened cast) it does not overage and lose hardness at elevated temperatures.

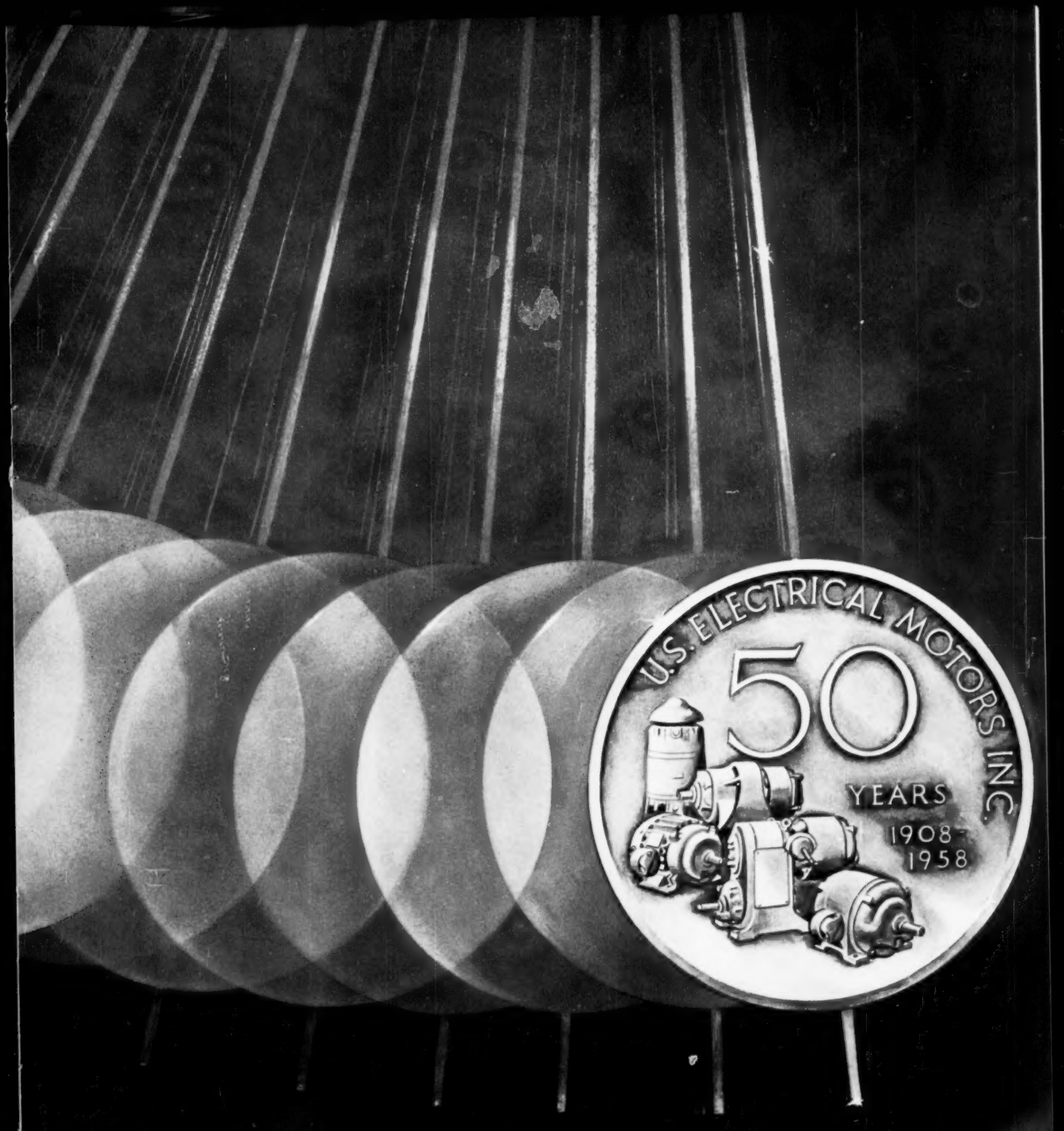
It maintains a Brinell hardness of above 300 at temperatures up to 1,400 F. for periods in excess of 50 hr.

V2B is annealed by water quenching from 2,000 F. As annealed, the alloy is readily machinable. It is hardened by aging at 925 F. for eight hours followed by air cooling. The slight discoloration obtained during aging can be readily removed by a short pickle in a dilute nitric-hydrofluoric acid mixture. In the annealed condition, the alloy is readily weldable using a special V2B welding rod.

The alloy combines good strength with excellent corrosion resistance and is, therefore, recommended for such applications as valve disks, shaft sleeves, impellers, pump casings, bearing rings, conveyer links, and other parts requiring wear, galling, and corrosion resistance.

▶ **CD4MCu Alloy**—CD4MCu is a recently developed high-strength corrosion-resistant casting alloy. Ultimate tensile strengths run to about 141,000 psi. for hardened alloy. While this alloy does not attain strengths as high as those of cast 17-4PH and V2B, it is reported to have corrosion resistance better than Type 302 in all media tested. In addition, the alloy has shown no corrosion in 10% sulfuric acid, 50% sulfuric acid, and 0.5% hydrochloric acid at room temperature. In 5% hydrochloric acid at 80 F., however, it showed rates of 60 mils/yr. or more.

The alloy can be machined more easily than Type 302 and is reported to be readily welded by conventional arc-welding.



HALF A CENTURY OF SERVICE TO INDUSTRY

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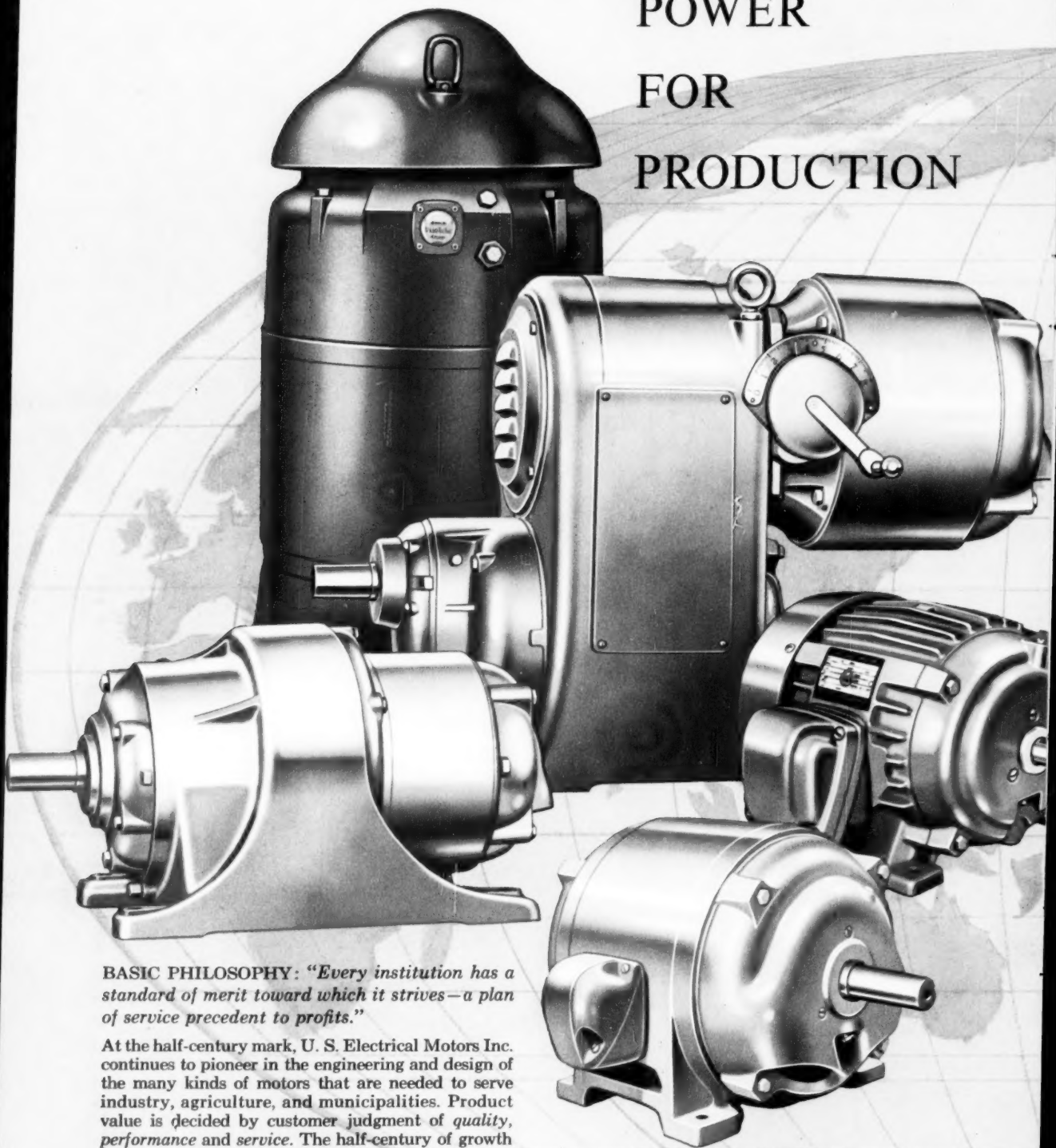

BASIC PHILOSOPHY: *"Every institution has a standard of merit toward which it strives—a plan of service precedent to profits."*

At the half-century mark, U. S. Electrical Motors Inc. continues to pioneer in the engineering and design of the many kinds of motors that are needed to serve industry, agriculture, and municipalities. Product value is decided by customer judgment of *quality*, *performance* and *service*. The half-century of growth achieved by U. S. Motors has been on the basis of that judgment by its customers.

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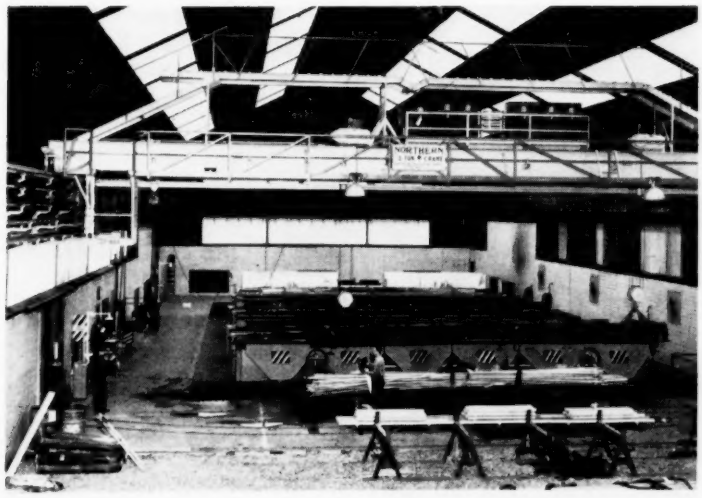
PEOPLE . . .

FIRMS IN THE NEWS

R. A. LABINE

NEW FACILITIES



Inco Inaugurates Molten Salt Pickling Process

International Nickel Co. has started up a modern $1.1-million pickling unit at its Huntington, W. Va., Works for descaling high nickel-chromium alloy products. Initial molten salt bath at 900 F. makes surface oxides more vulnerable to attack in subsequent pickling tanks; salt tank holds 111 tons of NaOH-NaCl-$NaNO_3$ mixture.

Celanese Corp. of America announces that it has completed construction of a new manufacturing unit to produce polyvinyl acetate emulsions at its Belvidere, N. J., plant. Annual capacity of installation is in excess of 20 million lb., most of this output will go into water-thinned latex paint.

Reichhold Chemicals has started producing epoxy resins at a 10-million-lb./yr. clip at its plant at Ballardvale, Mass. Consumption of these tough resins has been growing almost 50% annually.

Atlantic Refining Co. has completed a 2,100-bbl./day sulfuric acid alkylation unit at its Atreco refinery in Port Arthur, Tex. Feed stock for new unit comes from a cat cracker and two Catformers, one of which was completed last fall.

Henderson Sugar Refinery, Inc., has announced plans to spend $8 million building a new sugar refinery in Pascagoula, Miss. New refinery will process imported Cuban and Puerto Rican sugar.

Olin Mathieson is expanding facilities for paper products: At Joliet, Ill., firm will erect a corrugated shipping carton plant rated at 30 million sq. ft./mo. corrugated board; a similar plant is underway in Cincinnati. And at West Monroe, La., firm is slated to start production of folding cartons next fall.

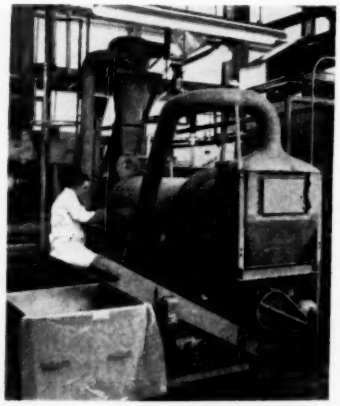
Dayton Rubber Co. expanded its activity in field of foamed plastic with the opening of the new Freedlander Research and Development Laboratories at Hawthorne, Calif. The 25,000-sq.-ft. structure will be devoted to basic re-

FIRMS . . .

search and product development of urethane foam.

Allied Chemical Corp. is installing two large-volume nitrogen solution storage terminals in Florida to supply Southeast fertilizer markets. Both will be located on the St. John's River, one at Jacksonville and one at Sanford.

Noralyn Paper Mills has acquired an option on a 280-acre industrial site on the Mississippi River south of Donaldson, La., for a proposed paper mill. Construction is slated to start in three months; initial newsprint production will utilize 150 tons wood pulp daily with later expansion to 250 tons.



R. J. Reynolds Tobacco Co. recently dedicated a new $2-million addition to its research laboratories at Winston-Salem, N. C. Shown above, researchers make up experimental blends in a tobacco manufacturing pilot plant.

The First Mississippi Corp. plans to build its third plant, a $225,000 phosphate unit, at Pascagoula, Miss., pending response to a $50,000 stock offering.

Norton Co. is already in production at its new $1.5-million special refractories plant in Worcester, Mass. Main innovation in plant is the gas-heated, humidity-controlled drying rooms which remove

Snap*On® pipe insulation specified as result of TEVA survey

TEVA (Thermo-Economic Value Analysis) is Gustin-Bacon's analytical approach to your pipe insulation requirements. TEVA compares G-B Snap*On, the one-piece pipe insulation molded of fine glass fibers, with other insulations *for your particular job.* Thermal efficiency of different insulations . . . wall thickness required . . . initial and operating savings . . . application conditions—all are analyzed and comparisons made to help you select the insulation best suited to the job at hand.

TEVA surveys reveal some startling advantages of Snap*On one-piece glass fiber pipe insulation. At one plant, for example, engineers determined that 1½" Snap*On was thermally more efficient than 2" of another insulation —and that they could save more than $10,000 on the cost of insulating material alone!

You'll soon discover that Snap*On has the highest thermal efficiency of any general-purpose pipe insulation up to 350° . . . that it is far easier and cheaper to apply because 3-ft. or 6-ft. one-piece sections simply snap on pipe. It's available for hot or cold lines, plain or jacketed, in sizes up to 33".

FOR A TEVA SURVEY, CALL YOUR LOCAL G-B INSULATION DISTRIBUTOR (LISTED IN THE ADJOINING COLUMN)

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Thermal and acoustical glass fiber insulations • Pipe couplings and fittings • Molded glass fiber pipe insulation

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WHY? *Increased inlet area!*

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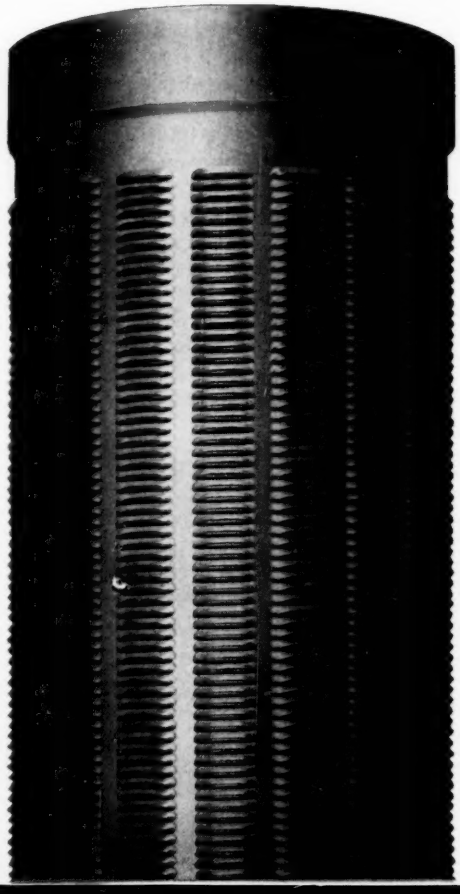
This new development of Layne creative research is used only in Layne water well installations, and available exclusively through Layne Associate Companies.

Contact your nearest Layne Associate Company for complete details.



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VERTICAL TURBINE PUMPS • WATER TREATMENT

moisture from refractory products prior to kiln firing.

Link-Belt Co.'s subsidiary, Link-Belt Speeder Corp. of Cedar Rapids, Iowa, is starting construction on a new plant in Woodstock, Ont., to manufacture power cranes, shovels and draglines.

MERGERS & ACQUISITIONS

Koal-Krudes of Spokane, Wash., has leased its char plant at Red Lodge, Mont., to Husky Oil Co. Lease provides an option for Husky to buy the firm within a year for $450,000. Red Lodge plant is designed to turn out high-grade industrial carbons and by-products.

Mallory-Sharon Metals Corp., major producer of reactive metals, has purchased the common stock of Johnston & Funk Titanium Corp., Wooster, Ohio, leading producer of titanium and zirconium wire and rod.

Anaconda Co. announces it has completed acquisition of assets and property of Cochran Foil Co., manufacturers of aluminum sheet, foil and laminated foil products.

Central Farmers Fertilizer Co. has picked up financial support from Western Fertilizer Assn. in building its $15.5-million calcium metaphosphate and elemental phosphorous plant at Georgetown Canyon, Idaho. Merger of interest provides CFFC with additional phosphate reserves as well as strengthened sales and financial position.

The Glidden Co. will acquire the domestic paint business of General Paint Corp., San Francisco, Calif., hinging on General Paint's stockholder consent. Glidden acquires brand names, paint processes, manufacturing units at Portland, Ore., and Tulsa, Okla., and distribution outlets on West Coast and in Southwest.

National Research Corp. has sold its interest in Escambia Chemical Corp. to Electric Band & Share Co. and United Gas Corp. These two firms had joined with National Research to organize and finance Escambia which has a $25-million plant at Pensacola, Fla., for producing ammonia, nitric acid, polyvinyl chloride and methanol.

Sunray Mid-Continent Oil Co. and Suntide Refining Co. plan to merge on Sept. 1, pending approval of both groups of stockholders.

Summit Chemical Co., newly formed chemical producer located in Denver, Colo., has brought the Service Supply Co., manufacturer of automotive chemicals for 28 years.

NEW LOCATIONS

Ever-Tite Coupling Co. has opened a new sales office at 600 S. Michigan Ave., Chicago 5, Ill., handling the complete line of company products.

Pacific Vegetable Oil Corp.'s Richmond, Calif., Div. has moved into a new headquarters building and laboratory at Richmond, transferring several operations from San Francisco.

Food Machinery & Chemical Corp., San Jose, Calif., has opened offices in Geneva, Switzerland, that will serve as a European liaison center for company's international operations.

Instron Engineering Corp., manufacturer of precision materials testing equipment, has completed a move to a new plant at 2500 Washington St., Canton, Mass.

CALENDAR

Fourth International Automation Exposition and Congress, Coliseum.
June 9-13 New York, N. Y.

Gordon Research Conference, Petroleum, Colby Junior College.
June 9-13 New London, N. H.

Gordon Research Conference, Metals at High Temperatures, New Hampton School.
June 9-13 New Hampton, N. H.

American Society of Mechanical Engineers, Materials Handling Conference and Exposition, Public Auditorium.
June 9-12 Cleveland, Ohio

Midwest Research Institute, symposium: Planned Experiments in Chemical Research, Hotel President.
June 11-12 Kansas City, Mo.

Manufacturing Chemists Assn., annual meeting, Greenbrier.
June 12-14 White Sulphur Springs, W. Va.

Chemical and Petroleum Exhibition, first annual exhibition in Britain.
June 18-28 Olympia, England

American Assn. of Cost Engineers, annual meeting, Case Institute of Technology.
June 16-18 Cleveland, Ohio

American Society of Mechanical Engineers, semiannual meeting, Hotel Statler.
June 15-19 Detroit, Mich.

Gordon Research Conference, Separation and Purification, Colby Junior College.
June 16-20 New London, N. H.

American Society for Engineering Education, annual national meeting, University of California.
June 16-20 Berkeley, Calif.

American Institute of Chemical Engineers, 50th Anniversary Meeting, Bellevue-Stratford Hotel.
June 22-27 Philadelphia, Pa.

American Society of Testing Materials, annual meeting and exhibition, Hotel Statler.
June 22-27 Boston, Mass.

Gordon Research Conference, Catalysis, Colby Junior College.
June 23-27 New London, N. H.

Gordon Research Conference, Nuclear Chemistry, Kimball Union Academy.
June 23-27 Meriden, N. H.

Society of the Plastics Industry, Midwest Section conference, French Lick-Sheraton.
June 26-27 French Lick, Ind.

Gordon Research Conference, Polymers Colby Junior College.
June 30-July 4 New London, N. H.

Gordon Research Conference, Solid State Studies in Ceramics, Kimball Union Academy.
June 30-July 4 Meriden, N. H.

PEOPLE . . . TECHNICAL

To Keep a Plant Going

PLANT ENGINEERING PRACTICE. By the editors of *Plant Engineering*. F. W. Dodge Corp., New York, in cooperation with the Technical Publishing Co. 694 pages. $18.50.

As the foreword says, "'Plant Engineering Practice' is not a handbook. It is not a manual. It is a compilation of carefully selected articles that appeared in *Plant Engineering* magazine in recent years."

And so it is. An excellent coverage of topics that relate to every aspect of plant operations and maintenance. Covered are such diverse topics as work simplification, fire protection, maintenance standards, corrosion, instrumentation, shop work, lubrication, industrial noise, to name a few.

Although the material is not directed towards the man in the chemical industry, any engineer concerned with keeping a plant going would benefit from this rather large but still handy reference.—MDR

To Keep Up-to-Date

CHEMICAL REACTION ENGINEERING. Edited by Dr. K. Rietema. Pergamon Press, Inc., New York. 200 pages. $12.50.

Reviewed by James O. Osburn, Department of Chemical Engineering, State University of Iowa, Iowa City.

More engineers read kinetics books now than ever, and for one of two reasons—to catch up or to keep up.

For the engineer who is just tackling this subject, this book will have little appeal. It doesn't claim to give a unified, easy, or comprehensive treatment of reaction engineering.

It contains, instead, 15 highly varied articles, by 17 authors, unconnected except for the general topic. A good introductory article which would help a be-

BOOKSHELF

J. B. BACON

ginner is in French; most American engineers would prefer English for learning the subject. Three articles are in German.

▶ **For Those Who Know**—The engineer who knows kinetics and wants to keep up-to-date will be interested in the book. The articles form a comprehensive survey of modern European thought in reaction engineering. Areas of opportunity are indicated more than once by the phrase "treatment becomes extremely difficult".

The articles are of three types —review, theory, and experimental.

Five articles review chemical kinetics, reactor design, and heat and mass transfer.

Six present new theory, on transport phenomena in heterogeneous reactions, incomplete mixing, two-phase reactions, exothermic processes, and optimum temperature sequences.

Four describe experimental work.

BRIEFLY NOTED

SPECIFICATIONS FOR RUBBER PRODUCTS. 51 *pp. Rubber Manufacturers Assn., 444 Madison Ave., New York 22, N. Y.* $1. Gives specifications for molded, extruded, lathe-cut and chemically blown sponge-rubber products.

CORPORATE DIAGRAMS AND ADMINISTRATIVE PERSONNEL OF THE CHEMICAL INDUSTRY. 65 *pp. Edited by Kenneth R. Kern. Chemical Economic Services, P. O. Box 468, Princeton, N. J.* $5. Gives listings of management and administrative personnel of 60 chemical processing companies, 40 shown by corporate charts.

MORE NEW BOOKS

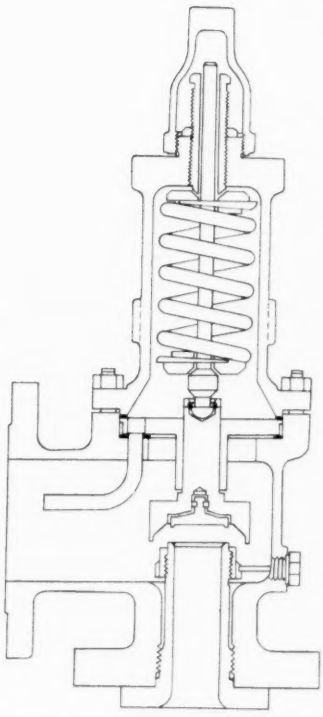
ION EXCHANGE RESINS, 2nd ed. By Robert Kunin. Wiley. $11.

PHYSICAL CHEMISTRY OF ELECTROLYTIC SOLUTIONS, 3rd ed. By Herbert S. Harned and Benton B. Owen. Reinhold. $20.

SURFACE CHEMISTRY, THEORY AND APPLICATIONS, 2nd ed. Academic Press. $15.

PEOPLE . . .

LETTERS:



Con: Low Safety Factor

Sir:

Mr. Bigham, in his article on spring-loaded relief valves (*Chem. Eng.*, Feb. 10, 1958, pp. 133-136), takes only one side of a very controversial question in his discussion of accidental fires (p. 135).

The formula $Q = 21{,}000\ FA^{0.82}$ appears in American Petroleum Institute's "Recommended Practice for the Design and Construction of Pressure-Relieving Systems in Refineries (Tentative), 1955," with derivation of the formula discussed in Appendix A and references cited in Appendix B.

These references are incomplete in two important respects. They do not mention "Requirements for Relief of Overpressure in Vessels Exposed to Fire," published in *Trans. ASME* (Jan. 1944), nor do they mention "The Design and Construction of Pressure-Relieving Systems," by Sylvander and Katz, published as Bulletin No.

PRO & CON

C. H. CHILTON

31, Engineering Research Institute, University of Michigan (April 1948). Both references cite additional tests which show heat-transfer rates to vessels exposed to fire ranging from 18,700 to 25,900 Btu./(hr.)(sq. ft.).

The API Tentative Standard Appendix A gives a log-log graph comparing the API formula with the test data. The formula gives a straight line running through the lowest point of 11 fire test results. This is the only graph I have ever seen drawn on the basis of one experimental point when ten others were available!

Justification for this action is that fire conditions in the field will never be so severe as they were in any of the tests other than the one arbitrarily selected. Premises of the API formula are:

- That an exposure fire will never occur on a day when there is not a high wind.
- That there will always be an efficient fire brigade on the scene of the fire within 2 or 3 min. after its initiation.
- That no large spill will ever be ignited.
- That insulation will never fail under fire conditions.
- That heat does not radiate higher than 25 ft. above a fire.
- That somehow if these conditions do exist something less than 1% of the heat from a fire is absorbed by the exposed vessel as radiant energy, whereas the test reported in the ASME paper showed that approximately 4% was absorbed.

A subcommittee of the general safety committee of Manufacturing Chemists' Assn. has investigated in considerable detail the problem of venting tanks exposed to fire. This committee has concluded that it is unwise to assume heat transfer of less than 20,000 Btu./(hr.)(sq. ft. of wetted surface) when the unit in question has a capacity of 50,000 gal. or less.

W. H. DOYLE
Factory Insurance Assn.
Hartford, Conn.

PRO & CON . . .

Sir:

Table A-1 of the API Tentative Standard cites heat-transfer rates of 5,400 to 32,500 Btu./(hr.)(sq. ft.).

Differences of opinion are welcome. They may lead to better protection of property and saving of human lives.

J. E. BIGHAM
Chemstrand Corp.
Pensacola, Fla.

Emphasis on Patents

Sir:

In your February 24 issue (pp. 121-136) there is an article on patent fundamentals. This article was very interesting, but the point in question is in your foreword to the article wherein you refer to "a recently issued composition-of-matter patent (which), if upheld, may curtail the research, development, design, construction and sales programs of some of the most influential companies in the chemical process industries."

Not having heard of this particular case, I wonder if you could give me any reference to it.

L. HODNETT
Canadian Refractories Ltd.
Montreal, Que.

► *We were referring, of course, to the Du Pont patent on linear or high-density polyethylene. An item on our contents page of the same issue covered this development under the headline, "New Emphasis on Patents." We are following the situation with the principal chemical companies involved and hope to come up with clarification and interpretation of what this will actually mean to chemical engineers.*—ED.

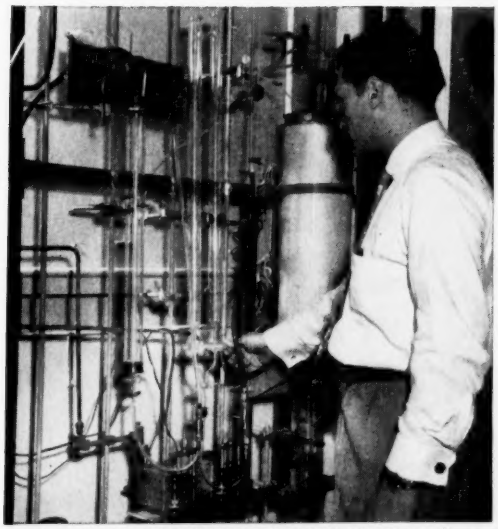
Never the Twain

Sir:

Like the report of his death, the report of what Mark Twain said about the weather (Apr. 7, p. 64) is often greatly exaggerated.

Samuel Dudley Warner, longtime editor of the Hartford *Courant* and friend of Mark Twain, originated the expression.

W. H. DOYLE
Factory Insurance Assn.
Hartford, Conn.



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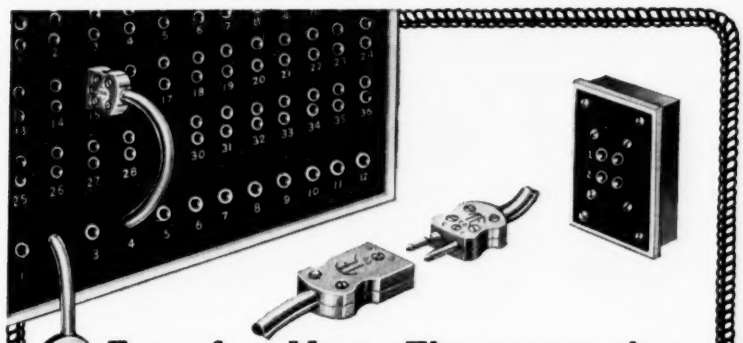

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Write for Bulletin 23 — E

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PEOPLE . . . NAMES IN

J. Howard Wright

Bauer Bros. Co., Springfield, Ohio, has appointed J. Howard Wright to the newly created position of technical director, food and industrial machinery division.

In his new position, Wright will conduct research on new and unusual applications of Bauer equipment for size reduction, granulating and fiberizing of various materials, especially for the chemical, food and allied industries. This is the second time he has been connected with Bauer. He was a sales engineer for the company from 1952 to 1957.

Before joining Bauer in his new position, Wright served with such firms as Doeskin Products, Rockland, Del.; S. Austin Bicking Paper Mfg. Co., Downingtown, Pa.; Hamilton Paper Co., Miquon, Pa.; Diamond Match Co., Plattsburgh, N. Y.

Charles J. Potter, president of Rochester & Pittsburgh Coal Co., has been elected to the board of directors, Vitro Corp. of America. Potter is also president of Vitro Minerals Corp. and Lucerne (Pa.) Coke Co.

T. H. Hopper, chief of industrial crops, Southern Utilization Research and Development Division, New Orleans, has been awarded the Honor Scroll of the Louisiana chapter, American Institute of Chemists, for his distinguished service to the profes-

THE NEWS

M. A. GIBBONS

sion of chemist and chemical engineer.

Harold F. Wood, Jr. has announced the formation of H. F. Wood Co., an industrial marketing firm with headquarters in Pittsburgh, Pa. Wood will serve as president of the new firm which will market products for the steel producing, steel fabricating, coal, paper, chemical and chemical processing industries in various sections of eastern states.

John Fischer

Author of . . . PRACTICAL PNEUMATIC CONVEYOR DESIGN. PAGE 114.

John Fischer is chief engineer of the materials handling division of Sprout, Waldron & Co., Inc. He joined the firm in 1955 after spending some years in a structural steel and welding shop. At first, he managed the shop but eventually he became its owner.

During the war years, he worked as a chemical development engineer for Sylvania Electric Products.

Fischer earned his bachelor's degree in chemical engineering from Yale in 1938. Recently, he obtained his professional engineering license for the State of Pennsylvania.

At home, Fischer enjoys spending time with his two children (9 and 13 years), golfing, saltwater fishing and collecting first editions of G. B. Shaw and Lewis Carroll.

NAMES . . .

Raymond C. Johnson

Raymond C. Johnson has joined the staff of the Manufacturing Chemists' Association, and will be identified primarily with MCA activities in the field of special metals.

Prior to his appointment, Johnson had been director of experimental development for the Lummus Co., New York City, where he specialized in the development of processes for production of titanium, zirconium and other special metals.

Before that, he served as vice-president and director of research for the Anthracite Institute, an industrial fellow at the Mellon Institute and U. S. Bureau of Mines, and research engineer for the Philadelphia and Reading Coal & Iron Co.

Elbert E. Husted has been appointed sales manager-fluorocarbon propellants, Union Carbide Chemicals Co. Husted, with headqaurters in New York City, will have charge of sales to the aerosol industry.

Roy E. Webb has joined van Amerigen-Haebler, manufacturer of perfume and flavor materials, and will be responsible for process development and pilot laboratory operations.

Herbert W. Mason, Jr., has returned to Reichhold Chemicals as administrative vice president, following a one-year leave of absence. Raymond W. Hargrove has been appointed sales manager, textile resins, Central Atlantic division of Reichhold. Hargrove will be headquartered in Charlotte, N. C.

Joe T. Kelly, formerly group leader in the petroleum section American Oil Co., has been promoted to section head, petroleum section of the company's research division of the research and development department.

H. H. Gott, former chief engineer for reactor design in the industrial power branch of Great Britain's Atomic Energy Authority, has been named nuclear plant design engineer of the Central Electricity Generating Board.

T. Q. Eliot

T. Q. Eliot of Texas Butadiene & Chemical Corp., Houston, has been appointed head of that firm's process technical service department.

Eliot, who has been with Texas Butadiene & Chemical since October 1957, will be responsible for process activities and economic evaluation of the corporation's new butadiene and aviation gasoline plant at Channelview, which came on stream early in 1957.

Before joining Texas Butadiene & Chemical, Eliot was process supervisor at Amoco's Brownsville, Tex., chemical plant, now closed.

Edmond S. Bauer has been promoted to the position of associate in Monsanto Chemical Co.'s plastics division development department at Springfield, Mass., after serving as assistant of sales for resin products since 1955.

James P. Brown has joined Anders Lykens Corp., a division

of Milton Roy Co., where he will be responsible for design and engineering of air and gas dryers. For over 20 years, Brown was associated with Smith, Drum & Co. where he was chief engineer.

John T. Rucker Jr. has been named manager of analytical and physical chemistry in the research and development department of Hooker Electrochemical Co., Niagara Falls, N. Y. Since 1957 he had been administrative assistant to the technical director, Clarence A. Stiegman.

Robert G. Koenig has joined the products research department of the soap products division of Procter & Gamble. **Alexander L. Liepa** has joined P&G's development department, foods division.

Irving P. Schwerd

Irving P. Schwerd has been appointed chief engineer of L. Sonneborn Sons' Belleville, N. J., manufacturing plant, succeeding Herberg Goldstein who has taken an assignment abroad for Sonneborn interests.

Schwerd, a chemical engineering graduate from the College of the City of New York, comes to Sonneborn from Otto B. May, Newark, N. J., manufacturer of dyes and chemicals, where he served as plant engineer from 1953 to 1957.

For three years, he served in the engineering department of Du Pont, and was engaged in process design. Schwerd is a veteran of U. S. Army service, and served in World War II as an instructor in chemical warfare.

H. A. Shabaker

H. A. Shabaker, of Houdry Process Corp.'s foreign operations engineering staff, has been appointed technical assistant to Theodore A. Burtis, corporation president.

A chemical engineering graduate from the University of Minnesota, Shabaker has been associated with Houdry since the company's founding in 1931.

He worked with Eugene J. Houdry in process development and catalyst manufacture for the original Houdry fixed-bed catalytic cracking units producing high octane motor fuel and aviation gasoline.

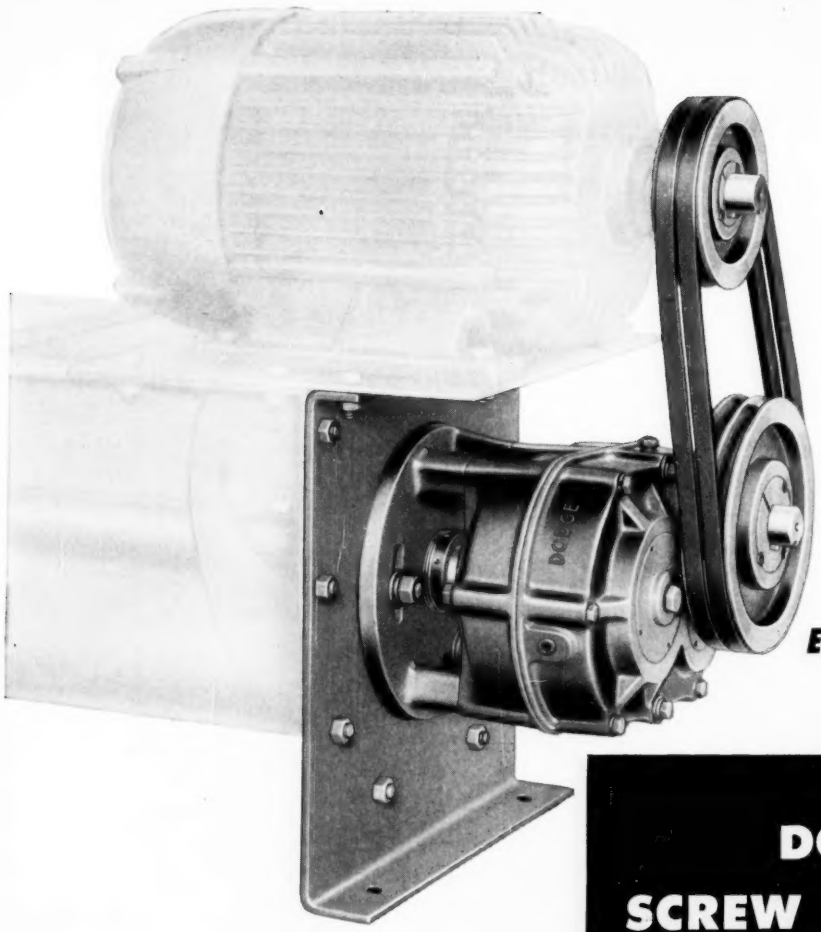
He also assisted in the designing of the world's first synthetic cracking catalyst plant, worked on the development of catalysts for other Houdry processes, and collaborated in the development of the Houdry single-step dehydrogenation process for the manufacture of butadiene from butane.

OBITUARIES

Karl Lark-Horovitz, whose basic research led directly to the $140 million transistor industry, died suddenly, April 14, in his office on the Purdue University campus. He was 65 years old.

George V. Slottman, 54, vice president—research and engineering of Air Reduction Co., died April 21 at Memorial Hospital, New York City, after a brief illness.

Philip Swain, 68, former editor of Power magazine, McGraw-Hill Pub. Co., Inc., and consultant in editorial techniques, died April 27 after a heart attack.



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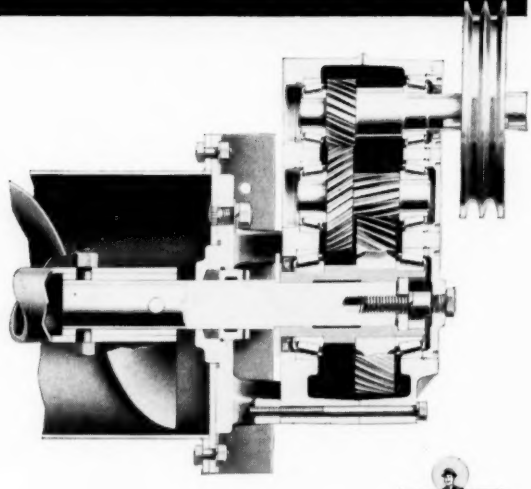

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Chemicals

N-Alkyl Trimethylene Diamines..... Duomeens are group of diamines which function as bacteriostats, flexible hardeners in epoxy resins, anti-stripping agents in asphalts, fuel additives in petroleum products.
164A Armour and Co.

Aminopyridines....."Reilly Aminopyridines" is product information booklet which gives physical constants of the pure compound of 10 aminopyridines, specifications and illustrative reactions.
164B Reilly Tar & Chemical Corp.

Benzoguanaine.....The triazine, benzoguanamine, is of principal interest as a raw material for resins by reaction with formaldehyde. Also has possibilities as an intermediate in pharmaceuticals, dyestuffs.
164C Rohm & Haas Co.

Carbon, Activated.....save 65% to 80% on solvent processing costs with efficient & economical activated carbon. Write for booklet, "Solvent Recovery by the Columbia Activated Carbon System".
R187 *Union Carbide Olefins.

Chlorine Compounds, Organic..... Eleven organic chlorine compounds are descrbied in 45 p. booklet which details compounds' physical and physiological properties, use information, handling and storage.
164D Union Carbide Chemicals Co.

Epoxides.....Bulletins 72, 73, 74, 81 & 82 describe veersatile expoxides. Whether you need a straight chain olefin oxide or a cyclic, terpene oxide, Becco has the epoxy chemical to fit your needs.
89 *Becco Chemical Division.

* From advertisement, this issue

LITERATURE

D. E. DETURO

Flotation Reagents.....Production of quality silica sand by flotation separation is done with anionic reagents—alpha sulfoalkyl acids and their derivatives. Some cationic reagents are also useful.
165A Armour and Co.

Fluorides & Fluorine.....a comprehensive new technical bulletin "Fluorine" will be sent you on request. Also Technical Bulletin TA-8532-2, covering Chlorine Trifluoride and other halogen Fluorides.
47 *Allied Chem., Gen. Chem. Div.

Laminates, Decorative.....Preparing decorative laminates from Dapon (diallyl phthalate) resin is described in 13 p. bulletin. Covers impregnation of papers, formulations, manufacture of laminates.
165B Food Machinery and Chemical Corp.

Laminates, Plastic.....Drawings, illustrations, text and charts are included in 28 p. technical plastics brochure describing full line of Synthane Corp.'s plastic laminates.
165C Synthane Corp.

Paint, Acrylic.....Formulation 178 has been developed to meet requirements of two recently issued government specifications for white acrylic emulsion paints for exterior use.
165D Rohm & Haas Co.

Pentaerythritol.....8 p. brochure covers Hercules' pentacrythritol—both Mono-PE and PE-200. Includes specifications and physical form, properties, quality control, packaging and availability.
165E Hercules Powder Co.

Polytetrafluoroethylene Resin.....Fluorosint TFE resin was designed to improve mechanical and thermal properties of pure polytetrafluoroethylene without affecting electrical, chemical characteristics.
165F Polymer Corp. of Pa.

Rubbers, Butadiene-Styrene.....Technical Data File on Synpols, Texas-U. S. Chemical's butadiene-styrene rubber, includes descriptions and specs, physical and chemical properties, standard test recipes.
165G Texas-U. S. Chemical Co.

*From advertisement, this issue

Contents of This Issue . . .

LITERATURE . . .

Silicones.....CDS-129, 8p. catalog, covers major GE silicone products and some of their many uses. Among materials described are silicone rubber, fluids, resins, water repellents, lubes.
166A General Electric Co.

Construction Materials

Brick, Refractory.....new, 24-page booklet is a dependable guide for your selection of the refractories you need to improve production & cut costs in high temperature processing. Send for it today.
57 *Norton Co.

Caulking Compound.....Vulc-Elastic No. 40 is putty-like compound that when mixed and applied gradually turns into a soft rubber. Compound is ductile at temperatures from —30 F. to 165 F.
166B Dittbrenner Associates.

Ceramic, High-Temperature.....Sur-Braze grade 120-F ceramic is designed for electrical and chemical insulators, brazing and heat-treating jigs for use at 2,000 F. Bulletin 107.
166C Duramic Products.

Coatings, Corrosion-Resistant.....for immersion duty, for heavy duty maintenance service, get PLASITE protective coatings, formulated with a combination of high resistant resins. Bulletin #258.
L172 *Wisconsin Protective Coatings.

Connectors & Panels, Quick-Coupling.....you now can transfer many thermocouples in a matter of minutes. Write for Bulletin 23-E for details on the connector panels & durable connectors you need.
BL155 *Thermo Electric Co.

Fillers, Non-Black.....Bulletin 104-4 covers evaluation of non-black fillers which couldn't logically be included in previous bulletins. Included are high specific gravity fillers, blanc fixe, lithopone.
166D Thiokol Chemical Corp.

Films, Polyester.....Application ideas for Scotchpak brand heat sealable polyester films are featured in new bulletin. Also included are properties and characteristics chart.
Minnesota Mining and Mfg. Co.
166E

Finishes, Vinyl.....Outstanding protective qualities as well as data regarding flexibility, adhesion durability, surface preparation, priming are described in bulletin on vinyl finishes.
166F Hauger-Beegle Associates.

Floors, Industrial.....stop corrosion in chemical processing areas. Resistant to widest range of acids, alkalies & solvents, constructed of acid brick. Write for Bulletin 3-3 for complete details.
L167 *Atlas Mineral Products Co.

Linings & Coatings.....solve corrosion & contamination problems—at less cost! Whatever size or shape, Lithcote can provide the lasting protection you want. For complete data get our new Catalog today.
150 *Lithcote Corp.

* From advertisement, this issue

LITERATURE . . .

Linings, Teflon.....dry chemicals flow smoothly thru Teflon lined equipment—the slipperiest, static-free solid material known. Cementable Teflon, with one side treated & ready for application. Bul. AD-169 *U.S. Gasket Co.

Metals.....Write today for our new booklet "Technical & Application Data on Zirconium & Hafnium" to help you work more efficiently & economically on nuclear or commercial applications. 36 *Mallory-Sharon Metals Corp.

Metal, Talide.....the hardest man-made metal, a tungsten carbide of superior quality, is harder, stronger, more resistant to abrasion than any other metal. Send for new 76-page catalog 56-G. 24 *Metal Carbides Corp.

Plastics.....complete line includes PVC pipe, fittings & valves. Stop corrosion the modern way with PVC custom molded parts, lining, roll coverings, & fabricated parts. Ask for Bul. PF-1200. L149 *Luzerne Rubber Co.

Polyethylene Components.....Catalog illustrates and describes line of semi-finished polyethylene components in branch and linear poly and polyvinyl chloride. Specifies sheet, rod, block, bars. 167A American Agile Corp.

Polyvinyl Chloride.....typical applications of PVC include process piping, tanks, tank linings & troughs, etc. Lightweight PVC licks 281 corrosives. Ask for your copy of illustrated bulletin 80-3 now. 110 *Jos T. Ryerson & Sons.

Steel, Stainless.....now—384 pages of practical data—the newest, most complete handbook of stainless steel fabrication—yours free for the asking. Write for your copy immediately. 98 *Alleghany Ludlum.

Electrical & Mechanical

Amplifier.....Wide band amplifier WA-600 allows complete coverage of 6-60 MC range without any adjustments or change in I.F. strips. Intended mainly for operation with pulsed oscillator. 167B Arenberg Ultrasonic Lab.

Chains.....ACCO X-Weld acid pickle chain and X-Weld type 321 stainless steel chain provide optimum service in high temperature applications and also in sulfuric or nitric acid solutions. 167C Amercian Chain & Cable Co.

Couplings.....Major products in John Waldron line include Waldron standard gear coupling, Francke Flexible, 162 "M" nylon gear coupling which needs no lubrication, Serrell Flexpin and Flexring. 167D John Waldron Corp.

Drives.....features of this new BH drive include wider bearing spread, pilot fit alignment, anti-friction bearings, no oil leakage, & fast changeovers. For complete data get Bulletin #972. 190 *The Pfauldler Co.

* From advertisement, this issue

LITERATURE . . .

Drives, Screw Conveyor.....a complete package drive with high-efficiency reducer, quick-removable shaft, external packing gland. Also sheaves, speed-reducers, & pillow blocks. Specify bulletin from ad.
162-3 *Dodge Mfg. Corp.

Drive Selective Speed.....8 p. bulletin describes motor speed control from alternating current. Devotes much space to what selective speed drive is; explains advantages. Bulletin 11-1, P1.
168A Century Electric Co.

Gearmotors & Motoreducers.....catalogs, price lists & selection tables of gearmotor speed reducers & motoreducers are available to power transmission engineers. Cover a wide range of ratios, hps.
R173 *D. O. James Gear Mfg.

Generator, Steam.....cuts fuel consumption 36%. If you need 10 to 600 HP & want space-saving, trouble-free service write today for Catalog. Save money—save time—with Amesteam Generator.
97 *Ames Iron Works, Inc.

Lubricators.....Write for complete catalog giving specifications & performance requirements to meet any of your lubricator needs. Remember the name—Manzel—specialists in lubricators.
152 *Manzel Co.

Motors, Open Type.....give double protection & can be used in many places that formerly required splashproof motors. Pack more power in less space with Wagner open & sleeve-bearing models.
26 *Wagner Electric Corp.

Packings.....are the positive answer to your tough-to-handle corrosive & toxic liquid problems at temperatures from —120° to +500°F. & without fear of contamination. Request Bulletin P-325.
148 *Crane Packing Co.

Power Supplies.....Catalog No. E-58 illustrates and describes a complete line of d.c. power supplies, a.c. line regulators and static inverters. Request catalog on company letterhead.
168B Perkin Engineering Corp.

Pulleys, Magnet.....Series 410 and 710 Indox V permanent magnet pulleys are designed for tramp iron separation in belt conveyor systems. Bulletin P-1021 discusses advantages over electromagnetic types.
168C Stearns Magnetic Products.

Rectifier Equipment.....custom engineered rectification in Semiconductor Power Conversion Equipment & Systems. Flexible modifying designs to meet specific needs. Send for Free "Guide".
168D Sel-Rex Corp.

Starters, Air Break.....operates 350 hp Pump Motor because of rugged & reliable air break contactors, no trouble in frequent ON-OFF service. Complete information is contained in Publication 6080.
84 *Allen-Bradley Co.

Transformers.....Types 117 and 217 Powerstat variable transformers deliver continuously adjustable voltage from a.c. power lines. Single units, two-gang, three-gang assemblies offered. Sheet SE-L2583.
168E Superior Electric Co.

* From advertisement, this issue

LITERATURE . . .

Turbines.....Simplified design includes reliable governing system with overspeed trip & valve positively insures smooth uniform speed day-after-day. Request Bulletin H-22B.
29 *Elliot Co.

Handling & Packaging

Cellophane.....Up-to-date price list includes several changes in price of cellophanes plus characteristics and uses of major types of Du Pont cellophane, yields, exclusive codes.
170A Du Pont.

Materials Handling....."7 Ways to Cut Costs" explains how material handling methods are developed through versatility of Payloader tractor-shovels. Machines have interchangeable front end attachments.
170B Frank G. Hough Co.

Materials Handling.....Free copies of the Spring issue of Lewis-Shepard Lever, 16 p. magazine, describes how wide variety of materials handling problems were solved in various industries.
170C Lewis-Shepard Products.

Heating & Cooling

Condensers, vapor.....Reduce operating costs with this air-cooled vapor condenser that gives more capacity at a saving of steam & power. For pure condensates, better recovery of residues send for Bul. 129R.
BL173 *Niagara Blower Co.

Cooling Towers.....Marlith Protected is synonomous with fungus-proof cooling tower service. If water conservation is in your plans, you'll find it profitable to investigate Marlith. Bulletin M-53.
19 *Marley Co.

Traps, Steam.....Request free booklet "The Why & How of Steam Trapping" for complete information on the most efficient traps & strainers on the market today. You can pick a Yarway impulse to order.
91 *Yarnall-Waring

Vaporizer, Packaged..... Produces closely controlled temperatures, can be outfitted for heating with oil, gas, waste heat. Complete line of process heating equipment. Full details covered in Bulletin "DV".
164 *Union Iron Wks.

Instruments & Controls

Air Velocity Measurement.....Velometer gives a simple, direct reading instantly. Measures air velocity through grilles, ducts, furnaces, or in the open. To get all the facts request Bulletin 2448-G.
R172 *Illinois Testing Labs.

* From advertisement, this issue

LITERATURE . . .

Alarm, Combustible Gas.....Features low cost & low maintenance, is small, completely self-contained, & has extreme zero & calibration stability. Write us for new bulletin on Explosilarm.
59 *MSA Instrument Div.

Control Centers.....Increased safety, flexibility, installation economy, space economy & superior design are the unique features of Square D Control Centers. Write for a complementary Bulletin now.
23 *Square D Co.

Electronic Control Systems.....Seven new, free booklets show how you can make present equipment electronic. Full details on how electronic control speeds weighing, accelerates materials flow,
14 *Fairbanks-Morse

Flow Controls.....Cepi automatic flow controls are designed to control flow of water to a specified gpm. rating at pressures between 15 and 125 psi. at a temperature to 160 F. Units handle flows from ¼-600 gpm.
171A Cepi-American.

Flowmeters....."How to Select Flowmeters" gives criteria for choosing the type of flowmeter to be used in measuring a given fluid or liquid. Advantages, limitations of basic types are charted.
171B Fischer & Porter Co.

Gages, Reflex.....with alloy Steel Bolts for high temperature service, interchangeable gaskets & cushions, extra heavy beam at end of frame to prevent distortion. Request Catalog 36 for full details.
185 *Penberthy Mfg. Co.

Radioisotope Instruments.....Catalog A-2 describes new systems for radioactivity studies; includes complete laboratories, scintillation spectrometers and medical systems, in detail.
171C Baird-Atomic, Inc.

Transmitter, Temperature Indicator.....compact, low-cost unit engineered for fast, sensitive response under roughest field conditions—uses any filled thermal system. Request Bulletin 456-20A.
37 *Foxboro Co.

Tube Systems, Pneumatic.....System transmits messages and samples between remote locations. Delivery time falls within a few seconds after dispatching. Either pressure or vacuum. Bulletin No. 12.
171D Standard Conveyor Co.

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Fittings, Welding.....any type of special fittings made from plate to the most rigid specification. Closer tolerances & quality control always beyond code requirements. Write for Bulletin 5801.
27 *Midwest Piping Co. Inc.

Nozzles.....if the liquid can be sprayed with direct-pressure rely on MONARCH advanced design Nozzles. Reduces clogging and guarantees dependable applications to food processing plants. Catalog 1.
R171 *Monarch Mfg. Works.

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LITERATURE . . .

Pipe & Tubing, Stainless Steel.....A completely equipped, modern plant able to offer stainless steel tubing in a wide range of standard A.I.S.I. analyses plus special alloy grades. Send for Catalog.
76 *Damascus Tube Co.

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92 *National Tube, Div. of U.S. Steel.

Tubing.....new tubing data book free! Complete technical data for designers & plant engineers includes specifications, applications & how to order interlocked & flexible tubing, expansion joints, etc.
L171 *Pennsylvania Flexible Tubing.

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TL187
*Crescent Insulated Wire & Cable.

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13 *Jenkins Bros.

Valves, Diaphragm.....widely used in processing industries where absolute tightness is necessary. Packless valves assure perfect processing. Circular AD-1942 tells all about them. Demand your free copy.
107 *Crane Co.

Valves, Relief.....Cash-Acme's F-2T series of pressure-temperature relief valves for water heaters feature side-mounted fusible plugs which facilitates plug replacement without removing valve.
172A A. W. Cash Valve Mfg. Corp.

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172B Fuller Co.

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25 *Shutte & Koerting Co.

Equipment, Rubber & Plastic.....fittings, valves, & linings in high-impact, rubber-plastic . . . economical & insensitive to corrosives. For more information on our complete line, specify bulletin from ad.
160-I American Hard Rubber Co.

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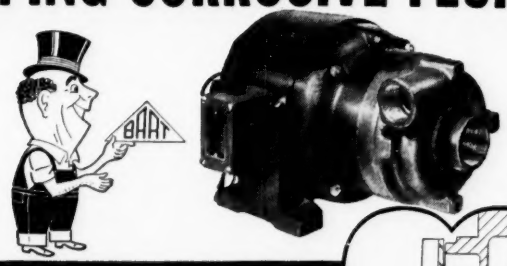
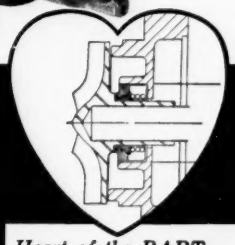
PUMPING CORROSIVE FLUIDS



BART

FLEX-SEAL

CENTRIFUGAL PUMPS



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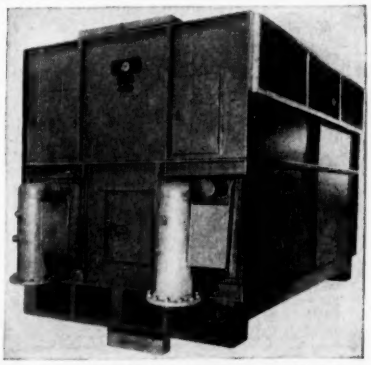

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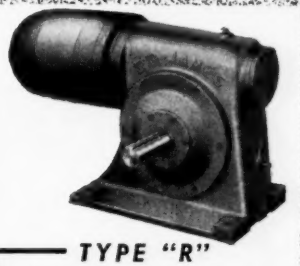

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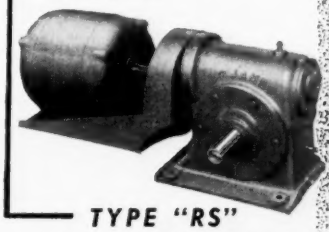

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30 *Process Filters, Inc.

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184 *W. W. Sly Mfg. Co.

Filters, valveless.....in same price range as manual filters, but completely automatic. Our new bulletin #4351 tells how you can cut both initial & operating costs with valveless filters.
106 *Permutit Co.

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39 *Traylor Engineering & Mfg.

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44-5 *Dorr-Oliver, Inc.

Regulator Vacuum.....provides superior performance at low cost in low pressure & vacuum service. Large metal bellows & tension-compression loading spring assure accurate control.
158 *Robertshaw-Fulton Controls Co.

Scrubber.....Bulletin 500 describes how Centrifix WD scrubber removes 99.5% or more of all solid or liquid entrainment in gas or vapor. Included are cut-away views of two types of scrubbers.
174A Centrifix Corp.

Wire Cloth.....Free 94-page catalog and stock list tells full range of wire cloth available, describes fabrication facilities and gives useful metallurgical data. Orders filled promptly.
178 *Cambridge Wire Cloth Co.

Pumps, Blowers, Compressors

Compressors, Air.....Joy compressors save you money where it counts the most. Eagle-eye installation + savings in maintenance & on operation. For a second look at our compressors get Bul. Sp. 243-11.
7 *Joy Mfg.

Compressors, Centrifugal.....designed for long life & high operating efficiency. Single- or multi-stage centrifugal compressors, turbine or motor drives, for handling air or gases. Bulletin P-7.
90 *Elliot Co.

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(*Continued from page 174*)

Fans, Centrifugal.....Bulletin BB-105 covers complete line of backward-blade fans—designed for use in heating-ventilating and air conditioning systems, power plant installations, industrial processes.
178A General Blower Co.

Pumps.....send today for the new 36-page catalog giving complete data on 274 General Purpose Viking Pump models. Viking is truly the pump designed to do your job better & more economically.
B140 *Viking Pump Co.

Pumps.....Whatever your pumping needs, why not write Tarer? Vertical pumps for molten chemicals, horizontal pumps for black liquor, caustic, etc. in evaporator service; for transfer of fluids in vacuum. Bulletin V-837.
144 *Taber Pump Co.

Pumps.....custom-built for efficient, dependable service, enclosed impeller & open impeller types. A maximum of service & output with a minimum of maintenance & down time. Bulletin #107.
L174 *Frederick Iron & Steel.

Pumps, Centrifugal.....Write for catalog & performance curves which detail a full line of pumps specifically designed to handle corrosive & abrasive fluids in the 1 to 80 GPM range.
TL173 *Bart Mfg. Corp.

Pump, Chemical.....no stuffing box, a piston-diaphragm pump providing positive displacement, prevents corrosion. Write for Bulletin 440 with typical applications, flow charts, types of models.
21 *Lapp Insulator Co.

Services, Processes, Misc.

Laboratory Equipment.....Steelab equipment—lab tables, storage cabinets, fume hoods, lab sinks, Labmaster lab service fixtures—are included in new, revised Catalog 585ST.
178B Laboratory Furniture Co.

Lighting, Mercury-Vapor.....Explosion-proof and dust-ignition-proof mercury vapor lighting fixtures are described in Bulletin 2705. Lamps provide high light output and long lamp life.
178C Crouse-Hinds Co.

Missiles.....8 p. guided missile data sheet contains information compiled from government services and is up to date as of Feb. 10, 1958. Lists names, purposes of all armed service missiles, prime contractors.
178D La Salle Steel Co.

Plastics Research.....“Our Lips Are Sealed” is a folder dealing mostly with what Evans Research has done in plastics and related fields. Includes 10 types of work done in these fields.
178E Evans Research.

Products, Services.....16 p. brochure describes products and services of Catalysts and Chemicals Inc. Includes coverage of staff, applied research, process engineering, manufacturing, current catalysts.
178F Catalysts and Chemicals Inc.

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EQUIPMENT SEARCHLIGHT

Continued on pages 180-183

JUNE SPECIALS

Day 40 gal. Pony Mixer with AC mtr.
Reactor, 125 gal. SS, Jktd. & Agtd. Exp. mtr.
Bowen Type 304 SS Lab. Spray Dryer
Baker Perkins 150 cu. ft. Jktd. Ribbon Mixer
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Baker Perkins 100 gal. S.S. double arm 50 HP jacketed, vacuum, hyd tilt.
Blaw Knox 2 gal. S.S. Autoclave 5000 lb.
50 gal. S.S. Autoclave 2000 lb. press.
Vulcanizer 60 in. x 9 ft. 125 lbs.
Oliver S.S. Pressure Filter.
Sweetland #2 all Stainless.
Stainless Steel Ball Mill.
Aluminum Condenser 350 sq. ft.
4-24 in. Filter Press S.S. Fittings Wd. Fr.
1-24 in. Filter Press open delivery.
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CENTRIFUGES:

1—Fletcher stainless steel 48" suspended type centrifuge, with perforate basket, complete with motor and plow.
1—Tolhurst stainless steel 32" suspended type centrifuge, with perforate basket, complete with motor and plow.
1—AT&M 42" suspended type centrifuge, complete with type 347 stainless steel perforate basket, plow and curb, with 40/20 HP motor.
1—Tolhurst 32" suspended type centrifuge with imperforate basket.

DRYERS:

4—Link Belt steel roto louvre dryers, Models 207-10, 310-16, 310-20, 604-20.
1—Stokes stainless steel rotary vacuum dryer, 3' x 15'.
1—Traylor rotary dryer, 4' x 40'.
1—Buflovak double drum dryer, 42" x 120".
1—Stokes Model 59 DS, steel rotary vacuum dryer, 5' x 30'.
2—Louisville rotary steam tube dryers, 6' x 50', complete.
1—Bartlett & Snow rotary dryer 4'6" x 36'6".
6—Stokes vacuum shelf dryers, 2, 4, 6, and 18 shelves.
1—Stokes double drum dryer, 5' x 12'.
1—Louisville rotary steam tube dryer, 8' x 45'.
1—J.P. Devine single door vacuum shelf dryer, 20 shelves.
1—Buflovak vacuum double drum dryer, 6" x 8".

FILTERS:

1—Oliver horizontal filter, 6'6".
1—Niagara stainless steel filter, Model 510-28.
1—Feinc stainless steel rotary string filter, 3' x 3'.
1—Sperry C.I. filter press, 24" x 24", 30 chambers, (New).
1—Oliver Horizontal 3' Pilot Plant Filter, New.
1—Sweetland #3 stainless steel filter, 70 sq. ft. filtering area.
1—Sweetland #7 filter with 20 steel leaves.
10—Sweetland #12 filters with 72 stainless steel leaves.
1—Sperry aluminum plate and frame filter press, 42" x 42", 33 chambers.

AUTOCLAVES, KETTLES & TANKS:

5—Pfaudler Series R, jacketed kettles, 1000 gallons.
20—Pfaudler, 1000 gallon vacuum receivers.
1—Glascote glass-lined jacketed kettle, 500 gal.
1—Stokes stainless steel 500 gal. jacketed vacuum kettle.
1—Downington Iron Works Steel Pressure Tank, 5000 gal. 200 PSI.
1—Nickel 1000 gallon jacketed kettle.
1—Lee jacketed stainless steel kettle, 125 gallons.
1—Pfaudler stainless steel jacketed kettle, 200 gals.
2—Stainless steel 5000 gallon horizontal storage tanks.
5—Aluminum storage tanks, 1750 and 12000 gals.
2—Pfaudler 100 gallon Type VR vacuum receivers.

THE GELB GIRL — JUNE 1958

MIXERS:

2—Robinson stainless steel horizontal ribbon blenders, 150 cu. ft. each.
1—Entoleter stainless steel continuous mixer, Type PF.
1—Abbe, Lennart Jacketed Mixer, 125 gallons.
1—Baker Perkins stainless steel double arm jacketed mixer, with compression cover, 2¼ gals.
1—Baker Perkins stainless steel double arm jacketed sigma blade mixer, 9 gals.
1—Patterson steel jacketed double arm vacuum mixer, 100 gallons.
1—Leader stainless steel jacketed horizontal ribbon blender, 40 cu. ft.
1—Patterson Monel Conical Blender, 4.7 cu. ft.
2—Baker Perkins double arm sigma blade jacketed mixers, 100 gallons.
1—Gedge Gray stainless steel ribbon blender, 65 cu. ft.
1—Banbury midget pilot plant mixer.
3—Robinson Type 316 stainless steel sigma type jacketed heavy duty mixers, 400 gallon capacity, 60 HP.
1—Process Engineers stainless steel jacketed ribbon blender, 30 cu. ft.
1—J. H. Day stainless steel jacketed double arm mixer, 1000 gals.

MISCELLANEOUS:

2—Williams hammer mills type 316 stainless steel, Model AK.
1—6" x 12" 3 roll laboratory calender.
4—Type 317 stainless steel heat exchangers, 892 sq. ft. each, 200 PSI.
6—Karbate 60 sq. ft. heat exchangers.
1—Combustion Engineers water tube package boiler, 200 HP, 375# pressure.
30—Struthers Wells stainless steel heat exchangers, 650 sq. ft. each.

4—Pfaudler glass lined jacketed reactors, complete with agitators and drives, 1000, 500, 300, and 100 gals.
3—Pfaudler glass lined jacketed kettles, Series ES, 100 gals.
1—Baker Perkins stainless steel double arm jacketed mixer, Size 20, Type JEM, 500 gal. capacity with hydraulic tilting device, complete.
1—Baker Perkins Type 316 stainless steel Ter Meer Centrifuge, Model HS-24".

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NICHOLSON

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This is the new BH drive

Its blueprint shows why it lasts longer, aligns faster, runs quieter.

Almost everyone who has seen the new Pfaudler BH Drive finds it hard to believe that it is a standard model sold at standard drive prices.

It includes many refinements which you normally expect only in a custom design.

Wider bearing spread

The widened bearing spread shown in this design cuts shaft whip and run-out to a minimum. Naturally, this increases seal life. The critical agitation speed is increased 50% over the previous design.

Pilot fit alignment

It takes only minutes to get perfect alignment. The drive is pilot fitted to the pedestal mount. It fits just one way—*the right way.*

Anti-friction bearings

All bearings are of the anti-friction type. Designed to exceed AGMA specifications, they can produce up to 300,000 hours of quiet, wear-free service under normal use.

No oil leakage

The oil reservoir of the BH Drive is a recessed well-type construction. The oil level is always below the seal. Oil just cannot slop over and seep down the shaft.

Fast changeovers

The new draw bar is keyed to the agitator. There are no threads to strip or stick. Tapered rings transmit torque when you draw the bar.

Either stuffing box or mechanical seal can be inserted without removing the drive from the vessel. Each comes as a unit called "Pfaudlerpac," and takes just minutes to install.

There's more

There are many other new features on the BH Drive, including hardened and lapped spiral bevel gears and a new motor mount.

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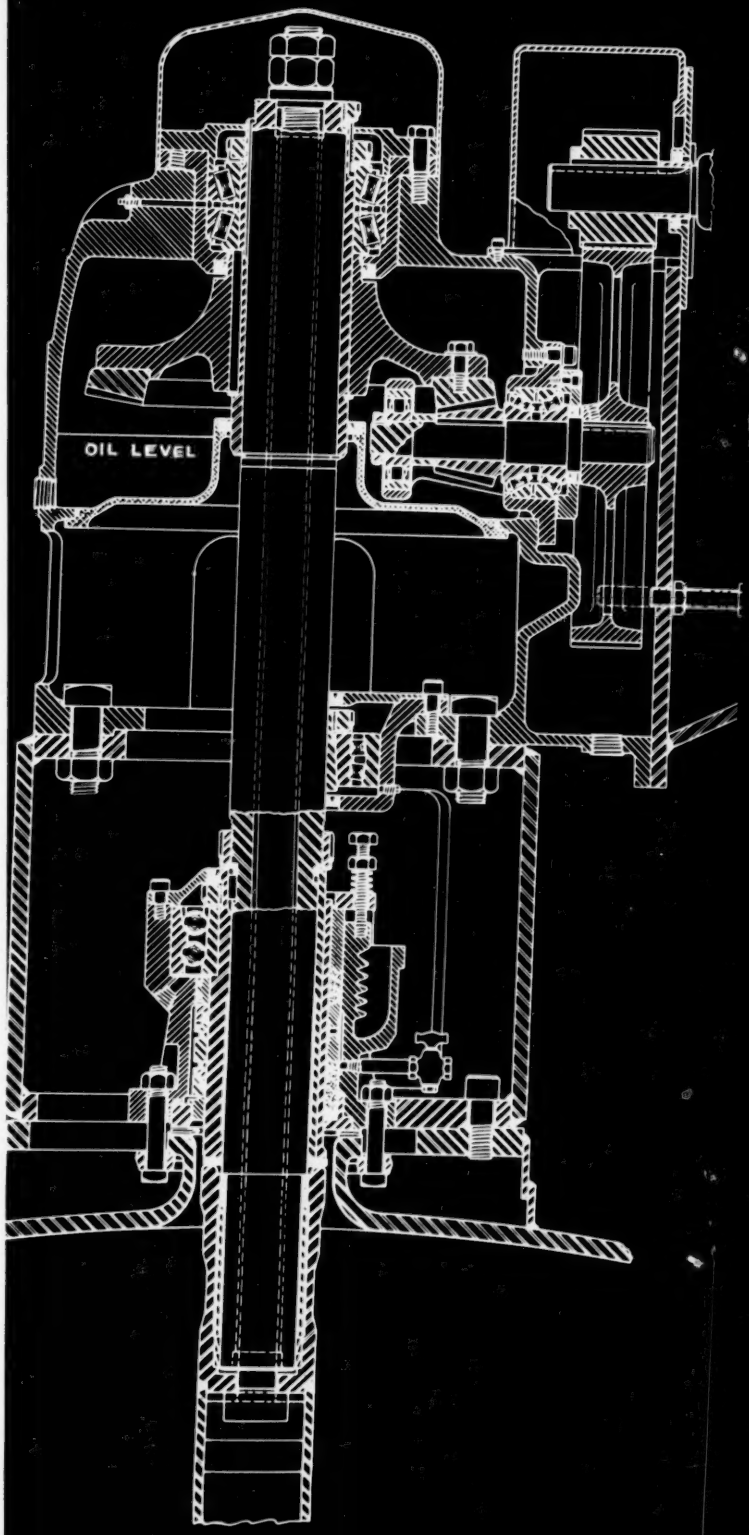

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